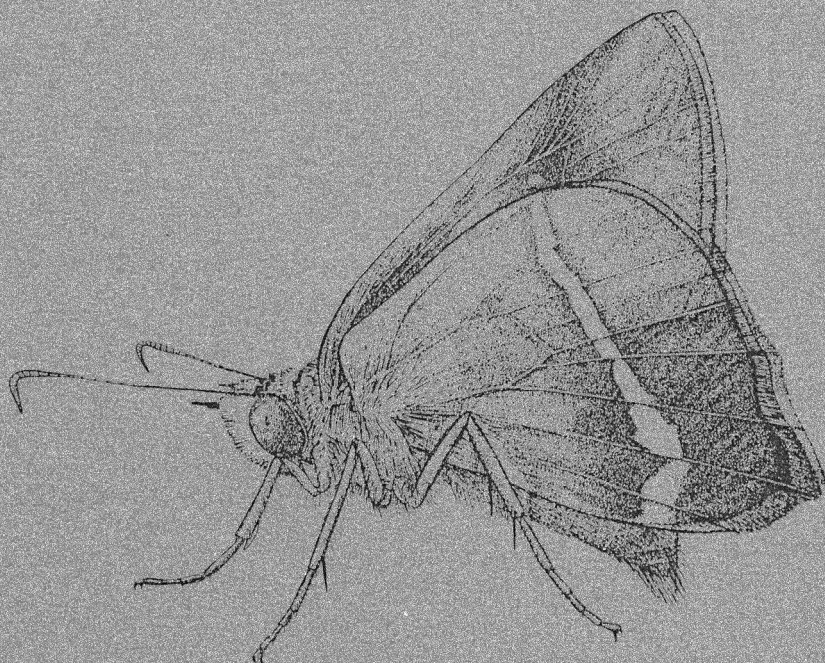


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Cover: A male Narrow-banded Awl, *Hasora khoda* (Hesperiidae: Coeliadinae). Occuring from New South Wales to central Queensland, this species flies at all times of the day, but usually at dusk and early morning. The larvae feed on *Wisteria* and *Callerya* (formerly *Millettia*). Awls are distributed from Africa and Madagascar to SE Asia and Australia. Many species are migratory. Their origin is obscure but their close relatives are the legume-feeding 'tailed skippers' (Eudaminae) of South America. They are a basal group of butterflies probably linked to Gondwana. Illustration by Andrew Atkins.

NEW RECORDS OF *HYPOLIMNAS BOLINA NERINA* (FABRICIUS) (LEPIDOPTERA: NYMPHALIDAE) FROM THE PILBARA REGION, WESTERN AUSTRALIA

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Abstract

New observations of the varied eggfly *Hypolimnas bolina nerina* (Fabricius) from the Pilbara region of Western Australia are presented, comprising a brief observation of a male from the town of Tom Price and observation of fresh males from near the town of Pannawonica.

Introduction

In Australia, the varied eggfly, *Hypolimnas bolina nerina* (Fabricius), occurs from the north-west of Western Australia, east through the tropical regions of the Northern Territory and Queensland and south along the east coast as far as Ballina, New South Wales (Braby 2000). It has also been recorded sporadically as far south as Victoria, in the Australian Capital Territory and westwards into South Australia and the Northern Territory (Braby 2000).

There are only a handful of published records from the Pilbara region of Western Australia (Williams *et al.* 1993, Williams and Tomlinson 1994, Williams and Williams 2006, Ginn *et al.* 2007). Previous records south of the Kimberley region include Onslow (Common and Waterhouse 1981), Exmouth (Williams *et al.* 1993, Williams and Tomlinson 1994), Carnarvon (Williams *et al.* 1993), a worn female from Karratha (Williams and Williams 2006), Mount Augustus National Park (Williams *et al.* 1993), Laverton (Williams and Williams 2006) and Mount Robinson (Ginn *et al.* 2007).

New Pilbara records

At least three males of *H. b. nerina* were observed near an area of damp herbland on a floodplain west of Pannawonica (21°38'17"S, 116°19'23"E), on 5 April 2006. The area of herbland was bordered by tall shrubs and was in close proximity to a section of creek containing free water. Males were observed perching between 1.5-2 m off the ground on outer branches of tall shrubs of *Acacia citrinoviridis* Tindale & Maslin (Mimosaceae), as well as making flights over the herbland at a similar height. One of the males was photographed, allowing closer observation of wing condition. The specimen was in fresh condition, showing no signs of wear or damage to the wings. In the four months leading up to this observation there had been above average rainfall in the region (*ca* 3 x average in February and March 2006).

In addition, a single male *H. b. nerina* was observed near some gardens in the town of Tom Price (22°41'38"S, 117°47'16"E), on 6 September 2008.

Discussion

The male photographed was in good condition. This, along with the perching behaviour is consistent with that of males holding territories waiting for

emergent females (Kemp 2001, Kemp and Rutowski 2001, Braby 2004). However, it remains uncertain whether these (and other) Pilbara records indicate the presence of an established breeding population in the region.

A broad range of food plants for *H. b. nerina* was summarised by Braby (2004). These include *Synedrella nodiflora* Gaertn. (Asteraceae), *Alternanthera denticulata* R.Br. (Amaranthaceae) and *Sida rhombifolia* L. (Malvaceae). While conducting a botanical rel  ve of the herbland, it was noticed that there was a high concentration of *Alternanthera* sp. present but further observations are required to establish if this is a larval food plant for the species in the Pilbara.

Acknowledgements

I thank Michi Maier, Paul Hoffman and Jodie Fraser for assisting with field observations; Andrew Williams for providing access to reference material; and Michael Braby for confirming identification, for comments and discussion regarding the observations and for assisting with improvements to an earlier draft of the manuscript. I also thank Pilbara Iron for funding the fieldwork.

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THE LIFE HISTORY AND BIOLOGY OF *EUPLOEA ALCATHOE ENASTRI* FENNER (LEPIDOPTERA: NYMPHALIDAE) FROM NORTHEASTERN ARNHEM LAND, NORTHERN TERRITORY, AUSTRALIA

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Abstract

The life history and general biology are described and illustrated for *Euploea alcatheae enastri* Fenner, which is endemic to Gove Peninsula in northeastern Arnhem Land, Northern Territory. The larval food plants include *Parsonia alboflavescens*, *Gymnanthera oblonga* and *Marsdenia glandulifera* (Apocynaceae) growing in relatively small patches of mixed paperbark tall open forest with rainforest elements in the understorey, usually in juxtaposition to wet monsoon forest (evergreen vine-forest), or in the ecotone between wet evergreen vine-forest and savanna woodland or paperbark woodland (*i.e.* rainforest edge); both habitats are associated with perennial groundwater seepages or springs in lowland coastal areas that may be flooded seasonally. *P. alboflavescens*, which likewise is restricted to Gove Peninsula, appears to be the preferred food plant. Adults appear to breed throughout the year and the life cycle from egg to adult is completed in about four weeks during the dry season. The early stages are briefly compared with those of *E. a. misenus* Miskin and *E. core corinna* (W.S. Macleay).

Introduction

The Gove Crow butterfly, *Euploea alcatheae enastri* Fenner, 1991 (Fig. 2), is endemic to the Northern Territory, where it is restricted to Gove Peninsula of northeastern Arnhem Land (Fenner 1991, 1992; Braby 2006), a remote and relatively pristine area of the 'Top End' (Woinarski *et al.* 2007). It is one of three subspecies currently recognised from Australia and its adjacent islands under the polytypic taxon *E. alcatheae* (Godart, [1819]) *sensu lato*, the others being *E. a. misenus* Miskin, 1890, from Torres Strait and *E. a. eichhorni* Staudinger, 1884, from Cape York Peninsula, Queensland (Braby 2000, Lambkin 2001, 2005). There is some evidence from the early stages to indicate that the most widely distributed subspecies, *E. a. eichhorni*, may actually be specifically distinct from *E. alcatheae* (Lambkin 2001), although Ackery and Vane-Wright (1984) were unable to find definite autapomorphies to define either *E. eichhorni* or the species *E. alcatheae*. *E. alcatheae* itself is most closely related to *E. climena* (Stoll, [1782]), another taxon which is poorly defined morphologically (Ackery and Vane-Wright 1984).

The life history of *E. alcatheae sensu stricto* has been well documented for subspecies *E. a. misenus* (Lambkin 2001), but the larval food plants, early stages and general biology of *E. a. enastri* have not been recorded previously. *E. a. enastri* males typically occur within or near the edge of patches of wet monsoon forest and have been collected feeding at flowers of *Leea rubra* Blume (Leeaceae) during the wet season, whereas females have been observed outside the monsoon forest, up to 20 m from the edge, feeding on *Melaleuca* flowers or seeking oviposition sites (Fenner 1991). For *E. a.*

misenus, the natural larval food plant in the northern Torres Strait Islands is *Gymnanthera oblonga* (Burm.f.) P.S.Green (Lambkin 2001), but adults have also been reared from pupae collected from the ornamental Oleander, *Nerium oleander* L. (Johnson and Valentine 1997). *G. oblonga* and *N. oleander* both belong to the milkweed family Apocynaceae, which now includes the Asclepiadaceae (APG II 2003). For *E. a. enastri*, Fenner (1991) observed a female apparently ovipositing on the young shoots of a vine, tentatively identified as *Tylophora benthamii* Tsiang (Apocynaceae), growing in rainforest edge about five metres above ground level. Subsequently, eggs, assumed to be those of *E. a. enastri*, were found on the underside of leaves of *T. benthamii* growing in swampland at the margin of monsoon forest at Gurrumuru, NT, in April 2003 (R.P. Weir and C. Wilson, pers. comm.) but the larvae failed to hatch. More recently, a female was observed ovipositing on *G. oblonga* at Rocky Bay, NT, in August 2005 and the early stages were subsequently reared to adult on this plant (L. Wilson, pers. comm.).

The purpose of this report is to document the life history and general biology of *E. a. enastri* and to clarify its larval food plants and breeding habitat. I also briefly compare the morphology of the early stages of *E. a. enastri* with those of *E. a. misenus* and *E. core corinna* (W.S. Macleay, 1826) and comment on the systematic relationships of the taxon within the *E. alcaethoe* complex.

Materials and methods

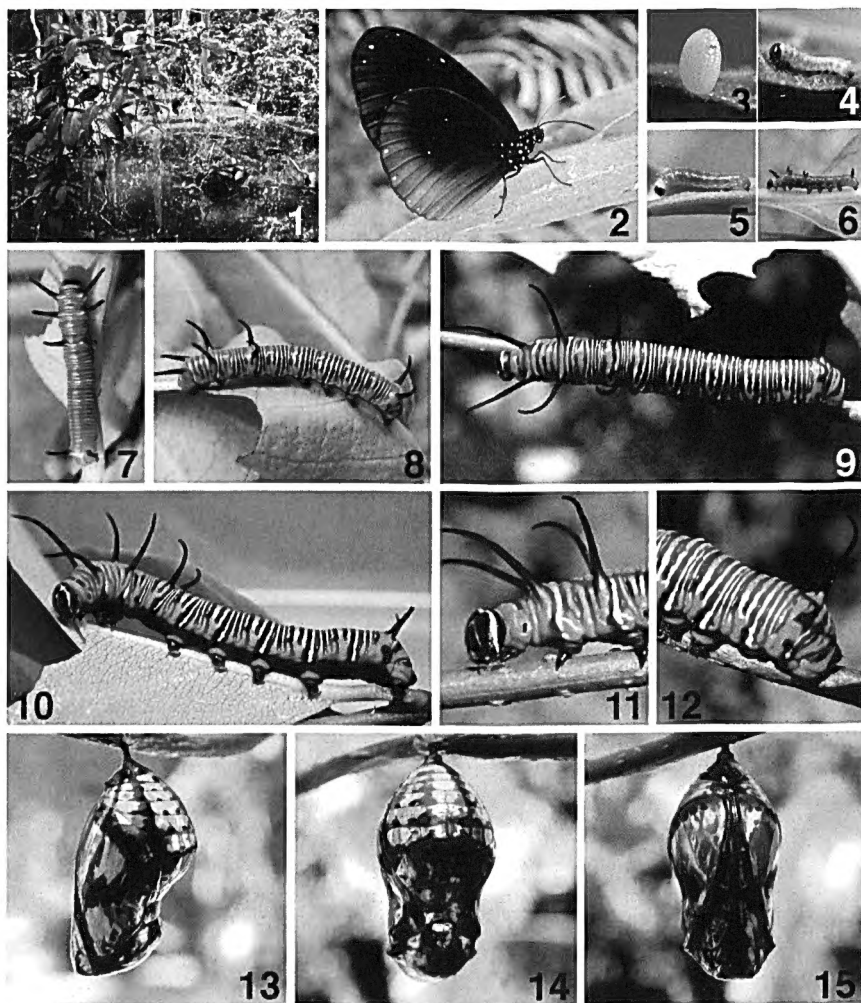
The following descriptions, illustrations and biological notes of the early stages of *E. a. enastri* are based on material collected from Gove Peninsula, NT. Most observations were made at a site near Yirrkala, Rocky Bay, in 2006 and 2007, with additional observations from sites at Gurrumuru, near Mt Bonner and Dhurputjpi in 2007 and 2008. The early stages of *E. a. enastri* were collected from the field and transported to Nhulunbuy or Darwin where they were reared in captivity on *G. oblonga* or *Parsonsia alboflavescens*. In addition, a small sample of females ($n = 6$) was collected from various populations on Gove Peninsula (Gapuwiyak, Gurrumuru, Rocky Bay) during the early dry season in June 2006 and August 2007 and dissected in the laboratory to ascertain their reproductive condition.

Life history

Larval food plants. *Parsonsia alboflavescens* (Dennst.) Mabb. (Fig. 1), *Gymnanthera oblonga* (Burm.f.) P.S.Green (Fig. 16), *Marsdenia glandulifera* C.T. White (Apocynaceae).

Egg (Fig. 3). 1.8 mm long; pale yellow; elongate and barrel-shaped, with apex somewhat flattened, and a series of approximately 20 longitudinal ribs and finer transverse lines.

First instar larva (Figs 4, 5). 7 mm long; head shiny black; body initially yellow on eclosion changing to semi-translucent orange-green after consuming food, with a darker green middorsal line and pair of small dull



Figs 1-15. Life history of *Euploea alcatheae enastri* from Gove Peninsula, NT: (1) larval food plant *Parsonsia albosflavescens* (in left foreground) growing in seasonally flooded mixed paperbark tall open forest with rainforest elements in the understorey, Rocky Bay; (2) adult male, Gurrumuru; (3) egg; (4) first instar larva, newly eclosed; (5) first instar larva, after feeding; (6) second instar larva, lateral view; (7) third instar larva, dorsal view; (8) fourth instar larva, dorsolateral view; (9-12) final instar larva, showing dorsal view, lateral view, anterior end depicting head and thoracic segments, and posterior end depicting abdominal segments 5-10; (13-15) pupa, showing lateral, dorsal and ventral views. Photos © M.F. Braby.

reddish-brown protuberances on mesothorax, metathorax and abdominal segments 2 and 8.

Second instar larva (Fig. 6). 15 mm long; head shiny black; body orange-brown to greenish-orange, with four pairs of short black fleshy dorsolateral filaments, one on each of mesothorax, metathorax and abdominal segments 2 and 8; prothorax with a pair of small black dorsal spots.

Third instar larva (Fig. 7). 26 mm long; head black, with a faint white transverse band; body orange, with four pairs of long black dorsolateral fleshy filaments on mesothorax, metathorax, abdominal segment 2 and abdominal segment 8; prothorax with two black subdorsal patches; abdominal segments 1-7 each with a series of faint white and black transverse bands; spiracles black.

Fourth instar larva (Fig. 8). 30 mm long; similar to fifth instar, but transverse bands less well developed.

Fifth instar larva (Figs 9-12). 50-55 mm long; head black, with a white transverse band, and a white inverted Y-shaped mark on adfrontal suture; prothorax orange, with a black subdorsal patch; meso- and metathorax each with two long black dorsolateral fleshy filaments (7-9 mm long), and a series of narrow black transverse bands broadly edged with orange, the middle orange transverse band white in lateral area; abdominal segments 1-7 each with an alternating series of six black and five white transverse dorsal bands, with the middle white transverse band extending to ventrolateral region, white transverse bands frequently orange or suffused with orange in middorsal area particularly on segments 1 and 2, a broad broken and irregular orange lateral band, and a pair of black dorsolateral fleshy filaments on segment 2; abdominal segment 8 orange, edged posteriorly with a narrow white transverse band and then a black transverse band, and with a pair of black dorsolateral fleshy filaments; abdominal segment 9 predominantly orange, narrowly edged with black transverse bands; abdominal segment 10 orange, with anal plate black; ventral surface black; legs and prolegs black, with basal area orange; spiracles black.

Pupa (Figs 13-15). 20-21 mm long, 9 mm wide; initially translucent pink, but after 24 hrs changes to shining silver with dark brown markings on wing cases and abdomen, or gold with pale brown markings on wing cases and abdomen; antennae and cremaster brown; spiracles black.

Biology

Adults of both sexes of *Euploea alacathoe enastri* were recorded in a variety of habitats on Gove Peninsula, including closed monsoon forest (i.e. wet evergreen vine-forest); rainforest edge (i.e. the ecotone between wet evergreen vine-forest and savanna woodland or paperbark woodland); mixed paperbark tall open forest or woodland (dominated by *Melaleuca leucadendra* (L.) L. or *M. cajuputi* Powell) with rainforest elements in the

understorey, usually in juxtaposition to wet evergreen vine-forest; and paperbark woodland (dominated by *Melaleuca* spp.) with pandanus (*Pandanus spiralis* R.Br.) in the understorey or mixed paperbark-pandanus woodland (M.F. Braby unpublished data). However, the larval food plants (Fig. 1) or early stages of *E. a. enastri* were found in only two of these habitats: the seasonally flooded mixed paperbark tall open forest with rainforest elements in the understorey, and rainforest edge that is less seasonally inundated with water. In both habitats, the breeding areas comprised relatively small patches of open forest or tall open forest associated with perennial groundwater seepages or springs in lowland coastal plains, usually surrounded by savanna woodland, paperbark woodland or sometimes open grassland floodplain depending upon hydrology.

The early stages of *E. a. enastri* were found on three species of plants at four locations on Gove Peninsula (Table 1). The main food plant, based on the frequency of field records, appeared to be *Parsonsia alboflavescens* (78% of all records) (Fig. 1), although the sample size was small ($n = 9$). Only single observations were available for the two other species. Larvae were found to readily consume *Gymnanthera oblonga* when reared in captivity regardless of the initial food plant on which eggs or larvae were associated. Although only eggs were found on *Marsdenia glandulifera*, there seemed little reason to doubt the suitability of this plant given that it is native to Australia and the general specialisation of *Euploea* Fabricius butterflies on vines in the Apocynaceae.

Females laid their eggs singly on the upperside or underside of new, small soft leaves growing near the apex of the larval food plant. Host suitability by ovipositing females involved a slow, hovering flight around the foliage of the food plant, followed by alighting on the upper surface of the leaves. This behaviour would be repeated many times until a leaf was eventually found suitable on which to deposit an egg. Such behaviour suggested that both visual and tactile cues were used to determine host suitability. Following hatching, the newly emerged larva consumed the chorion before proceeding to notch the mid vein of the leaf or graze a small semi-circular section from near the margin of an adjacent larger leaf. The first instar larva then proceeded to eat whole sections of leaf tissue from the margin of the new soft developing leaf on which the egg was initially laid. During development, the early instar larvae ate in short bursts and, when not feeding or moulting, retreated lower down on the vine to rest on the underside of a larger mature leaf. Later instar larvae also ate in bursts on young but fully expanded leaves; between meals, they remained on the underside of the same leaf being consumed. In captivity, all larval instars were noted to consume only the younger leaves and were reluctant to eat older leaves. Before consuming a leaf, a fine silken trail was laid over the surface to aid in mobility. Larvae were also observed to eat the cast larval skin after each moult. Prior to pupation, the final instar larva spun a silken platform on the underside of a

Table 1. Summary of field observations on the larval food plants and early stages of *Euploea alcatheae enastri*. LFP = larval food plant.

Larval food plant	Early stages	Locality / observer
<i>Gymnanthera oblonga</i>	Female observed ovipositing on LFP in Aug. 2005; several adults reared in captivity on <i>G. oblonga</i> .	5 km SSE of Yirrkala, Rocky Bay. L. Wilson
<i>Marsdenia glandulifera</i>	2 eggs collected from underside of new soft leaves of LFP on 3.ix.2007; 1 female reared in captivity on <i>G. oblonga</i> (larva pupated 19.ix.2007; adult emerged 28.ix.2007).	5.5 km NW of Mt Bonner. M.F. Braby, P. Wise & B. Marika
<i>Parsonsia alboflavescens</i>	5 eggs and early instar larvae collected from upper and underside of leaves of LFP on 22.iii.2006; 2 adults reared in captivity on <i>G. oblonga</i> .	5 km SSE of Yirrkala, Rocky Bay. M.F. Braby & L. Wilson
<i>Parsonsia alboflavescens</i>	Female observed ovipositing a single egg on upperside of new soft leaf of large vine of LFP at 1130 hrs on 3.vii.2006; a second female observed ovipositing on a different vine of LFP at 1215 hrs; a third female inspected another vine of LFP for suitability at 1230 hrs but did not oviposit; 1 male reared in captivity on <i>G. oblonga</i> (egg hatched 5.vii.2006; larva pupated 21.vii.2006; adult emerged 31.vii.2006).	5 km SSE of Yirrkala, Rocky Bay. M.F. Braby
<i>Parsonsia alboflavescens</i>	3 eggs collected from underside of new soft leaves of LFP on 30.viii.2007; adults reared in captivity on <i>P. alboflavescens</i> .	5 km SSE of Yirrkala, Rocky Bay. M.F. Braby, P. Wise & B. Marika
<i>Parsonsia alboflavescens</i>	1 dead pupa collected suspended beneath leaf of <i>Horsfieldia australiana</i> c. 1 m above ground level and 2 m from large vine of LFP on 31.viii.2007; 3 adult <i>Euploea darchia</i> feeding from contents of pupa.	5 km SSE of Yirrkala, Rocky Bay. M.F. Braby & P. Wise
<i>Parsonsia alboflavescens</i>	1 pupal exuvia collected from beneath broad leaf of <i>Carallia brachiata</i> c. 1 m above ground level, around which the LFP grew, on 31.viii.2007.	5 km SSE of Yirrkala, Rocky Bay. M.F. Braby & P. Wise
<i>Parsonsia alboflavescens</i>	1 egg collected from underside of new soft leaf of LFP on 20.vi.2007 and reared to instar IV in captivity on <i>P. alboflavescens</i> (egg hatched 22.vi.2007; larva moulted to instar II 24.vi.2007, instar III 26.vi.2007).	Goromuru River, 1.5 km WNW of Gurrumuru outstation, Arnhem Bay. M.F. Braby
<i>Parsonsia alboflavescens</i>	1 egg collected from underside of new soft leaf of LFP comprising small vine growing on forest floor on 2.x.2008; male reared in captivity on <i>P. alboflavescens</i> (egg hatched 3.x.2008; larva pupated 18.x.2008; adult emerged 26.x.2008).	5 km W of Dhurputjipi outstation. M.F. Braby & S. Gregg

leaf to which the pupa was attached by the cremaster and suspended upside down. In the field, pupae were not detected on the larval food plant, but were found on the underside of large leaves of two rainforest trees (non-larval food plants) growing adjacent to *P. alboflavescens* (Table 1), which suggests that larvae leave the food plant to pupate elsewhere. Final pupal colour appeared to be dependent upon the background colour. In captivity, adults emerged soon after dawn.

Males flew with a slow, gliding flight from around mid morning to mid afternoon in sunny glades, from within a few metres of ground level to near the canopy (10-30 m); during the cooler hours of the morning, late afternoon or when conditions were overcast, they were usually observed at rest in shade on the upper surface of large leaves. Both sexes were observed feeding avidly from flowers from a range of plants, often high up in the canopy, particularly *Melaleuca* spp. in the early dry season, but also *Carallia brachiata* (Lour.) Merr. in late August-early September (during early to mid afternoon), *Marsdenia geminata* (R.Br.) P.I.Forst. (Apocynaceae) in late September (at 1100-1130 hrs), *Ixora timorensis* Decne. (Rubiaceae) in late September (at 0920 hrs), and *Vavaea australiana* S.T.Blake (Myrsinaceae) in early October (at 1615-1630 hrs). A pair was observed flying *in copula* in late August 2007 at 1350 hrs at a breeding site at Rocky Bay.

Adults were recorded during most months of the year except November and January, two months that were not sampled in the present study. Limited observations on ovipositing females, mating and the temporal occurrence of the early stages (Table 1) indicated that breeding occurred from at least March to October. However, unlike other danainae, such as *E. core corinna*, *E. sylvester pelor* Doubleday, 1847 and *E. darchia darchia* (W.S. Macleay, 1826), with which it co-occurred, *E. a. enastri* did not form large overwintering clusters during the dry season, although small numbers were sometimes found aggregated in paperbark woodland close to the breeding areas, but only during June and July. Of the sample of females collected during the early dry season and dissected in the laboratory to assess their reproductive status, four individuals (67%) had no chorinated eggs in the oviduct but the ovaries contained eggs in various stages of development, while two individuals (33%) had small numbers of eggs (1-2) present in the oviduct. However, the body cavity of all individuals contained large amounts of yellow fat bodies, and each specimen contained several large intact spermatophores.

A male reared on *G. oblonga* in captivity at Darwin, from an egg laid in early July 2006, completed its life cycle in 28 days, and another male reared on *P. alboflavescens* in captivity at Darwin, from an egg collected in early October 2008, completed development in 23 days (excluding egg) (Table 1). Similarly, a female reared on *G. oblonga* at Nhulunbuy, from an egg collected in early September 2007, completed development in 25 days

(excluding egg) (Table 1). The overall duration of the early stages was as follows: egg 2 days, larva 15-16 days (duration of instars: I 2 days, II 2 days, III 1-2 days, IV 2 days, V 8 days), pupa 8-10 days. The longevity of adults was not determined but, like other danaines, they are probably long-lived, possibly up to six months or more (Ackery and Vane-Wright 1984).

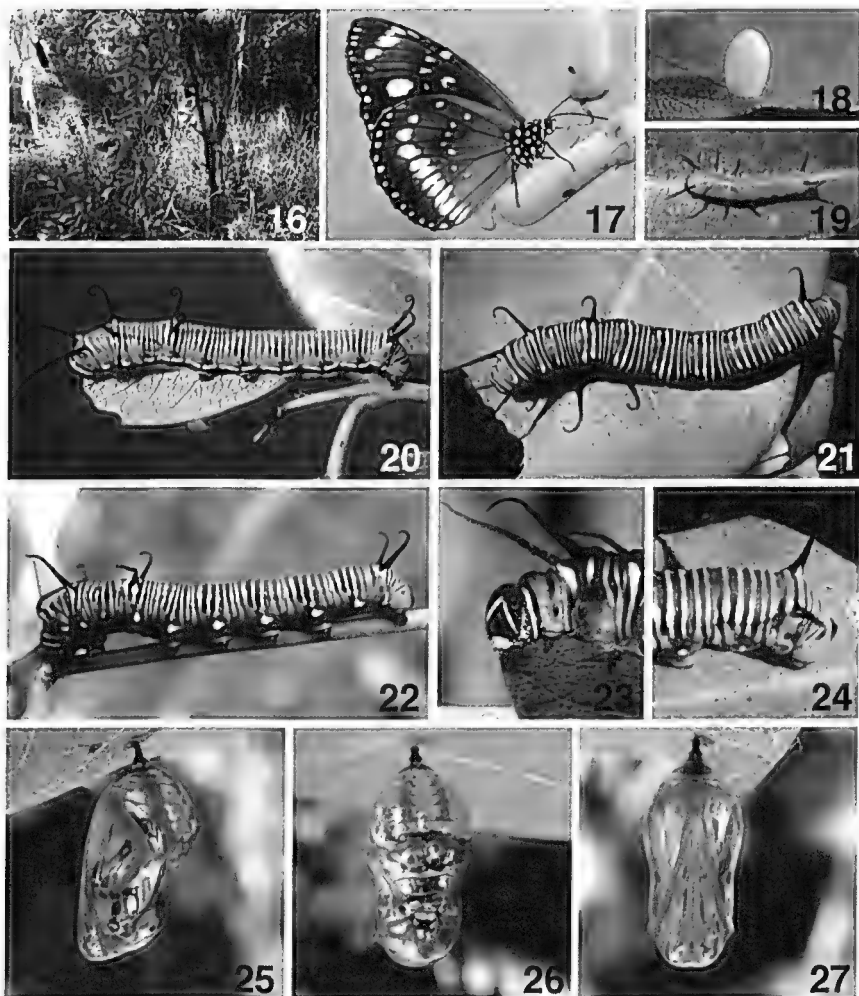
Discussion

Observations made on Gove Peninsula indicate that *Euploea alcatheae enastri* utilises at least three native larval food plants, of which one is shared with *E. a. misenus*. Further work is needed to determine the relative frequency of usage among these plants, and to confirm if *Tylophora benthamii* is also used, but preliminary observations suggest that *Parsonsia alboflavescens* is the preferred host. Within Australian limits, *P. alboflavescens* is restricted to northeastern Arnhem Land, NT, where it grows as a scrambling vine or tall climber with twining stems (Forster and Williams 1996); on Gove Peninsula it was only found in rainforest edge (i.e. the ecotone between wet evergreen vine-forest and paperbark woodland or savanna woodland) and the seasonally flooded mixed paperbark tall open forest with rainforest elements in the understorey where the vine frequently ascended the canopy via the trunks of paperbarks, particularly in long-unburnt sites. In contrast, *Marsdenia glandulifera* is endemic to northern and eastern Australia, occurring from the Kimberley across the Top End to Cape York Peninsula, as well as in southeastern Queensland, where it grows as a woody vine with white latex, often in rainforest swamps (Forster *et al.* 1996). *Gymnanthera oblonga* is also widely distributed and occurs in wider array of habitats throughout northern Australia in flooded coastal areas, such as edges of mangroves and along watercourses, where it grows as a tropical woody scrambler or liana (Forster *et al.* 1996). *T. benthamii*, which closely resembles *M. glandulifera*, except is characterised by yellow latex, is reasonably widespread in vine-forests in the Top End and occurs patchily in coastal rainforest areas of Queensland; it also grows as a woody liana (Forster *et al.* 1996). Thus, of the four potential larval food plants, one is restricted in range while the three others occur more widely outside the natural range of *E. a. enastri*. This suggests that the butterfly may be opportunistic, breeding on a suite of vines in the Apocynaceae that are locally available. On the other hand, if *P. alboflavescens* proves to be the primary food plant of *E. a. enastri*, then the other species may serve to supplement the diet, particularly if new growth of *P. alboflavescens* is temporally or spatially limited. If *P. alboflavescens* is indeed the preferred larval food plant then the limited occurrence of this species in the Top End may partly explain the restricted occurrence of the butterfly to northeastern Arnhem Land.

Little information on the ecology, behaviour and reproductive biology of *E. a. enastri* has previously been recorded, although some details have been documented for the closely related *E. a. misenus* (Lambkin 2001). The life

cycle of *E. a. misenus*, from egg to adult, is completed in approximately four weeks during March (Lambkin 2001), which agrees with observations made on *E. a. enastri* in which the life cycle is also completed in about four weeks during July–October. Limited observations on ovipositing females, mating behaviour and the temporal occurrence of the early stages suggest that breeding on Gove Peninsula occurs continuously from at least the late wet season (March) to the mid dry season (October). Adults of several other species of *Euploea* and *Tirumala hamata* (W.S. Macleay, 1826) are known to migrate and/or aggregate in large numbers during the winter-dry season in northern Australia (Monteith 1982, Kitching and Scheermeyer 1993, Scheermeyer 1993, 1999). Many of these species, including *E. sylvester* (Fabricius, 1793), *E. tulliolus* (Fabricius, 1793), *E. core* (Cramer, [1780]) (Fig. 17) and probably *E. darchia*, stop breeding during the dry season. It is not known if breeding in *E. alcatheae sensu stricto* is also seasonal, or if females enter reproductive diapause during the late dry season. However, limited observations made on the reproductive condition of *E. a. enastri* females and aggregation behaviour in non-breeding habitats during June–July, suggest that reproductive activity declines with the onset of the cooler winter dry season, but females do not stop breeding and enter reproductive diapause. Further field observations and comparative data for the late dry season (November–December) and early wet season (January–February), however, are needed to confirm this supposition. Lambkin (2001) noted that adults of *E. a. misenus* were most abundant during the wet season, from December to May, and suggested that breeding for this subspecies is limited to this period. He observed that the early instar larvae were dependent upon the young, soft foliage of the larval food plant, which is seasonally available in the late wet season. Although the climate is strongly monsoonal with most of the rain falling between November and April, the dry season in northeastern Arnhem Land is less pronounced and severe, being characterised by cooler and more humid conditions compared with the rest of the Top End, Torres Strait and northern Cape York Peninsula, so that the larval food plants continue to produce new growth at this time. Hence, it is likely that *E. a. enastri* breeds throughout the year.

Several species-groups of *Euploea* butterflies, including *E. alcatheae sensu lato*, are taxonomically complex and morphological data from their early stages may help elucidate their status and systematic relationships. The early stages of *E. a. enastri* provides additional characters for comparison with those reported for other subspecies in Australia, particularly *E. a. misenus* (which is well known) from the Torres Strait Islands (Lambkin 2001) and *E. a. eichhorni* (which is poorly known) from Cape York Peninsula (McCubbin 1971). The early stages of *E. a. enastri* are identical to the general descriptions and illustrations given for *E. a. misenus* (Lambkin 2001) but seem to differ from those of *E. a. eichhorni*. Several differences between the final instar larvae of *E. a. misenus* and *E. a. eichhorni* were noted by



Figs 16-27. Life history of *Euploea core corinna* from the Top End, NT: (16) larval food plant *Gymnanthera oblonga* (in left foreground) growing in paperbark woodland, Adelaide River; (17) adult male, Darwin; (18) egg; (19) third instar larva, dorsal view; (20-24) final instar larva, showing dorsolateral view, dorsal view, lateral view, anterior end depicting head and thoracic segments, and posterior end depicting abdominal segments 6-10; (25-27) pupa, showing lateral, dorsal and ventral views. Photos figs 16, 18-27 © M.F. Braby, fig. 17 © A. Hope.

Lambkin (2001), particularly in the body colour, pattern of transverse bands, relative length of the black fleshy filaments on the metathorax and abdominal segments 2 and 8, and presence of a white lateral band (which is absent in *E. alcatloe sensu stricto*). This suggests that *E. a. misenus* may be more closely related to *E. a. enastri* than to *E. a. eichhorni*, despite the fact that *E. a. misenus* and *E. a. eichhorni* both occur in northern Queensland and are separated geographically from *E. a. enastri* by the Gulf of Carpentaria.

The early stages of *E. a. enastri* are similar to those of *E. core corinna* (Figs 16-27) and, to some extent, *E. sylvester pelor* (Meyer 1997), two species which breed on similar larval food plants in the same habitat as *E. a. enastri* in northeastern Arnhem Land (M.F. Braby, unpublished data). While the early stages of *E. alcatloe sensu stricto* and allied taxa, including *E. c. corinna*, are very similar morphologically, Lambkin (2001) noted that the final instar larva of *E. a. misenus* was characterised by an extensive orange colouration, with the white markings less extensive or poorly developed. The following comparative differences in the final instar larva and pupa of *E. a. enastri* and *E. c. corinna* are provided to enable separation of the two species in the field. The larva of *E. c. corinna* (Figs 20-24) has a narrow but conspicuous white lateral band along the length of the body (sometimes this band is broken into a series of spots – see Fig. 22), whereas in *E. a. enastri* this band is absent. In *E. a. enastri*, the middle white transverse dorsal band, of the five bands on each body segment (from the mesothorax to abdominal segment 7), extends to the ventrolateral region, whereas in *E. c. corinna* this band stops well before the broad orange lateral band. In *E. c. corinna*, the pair of black fleshy filaments on the mesothorax, metathorax and abdominal segments 2 and 8 arise from a white patch and/or the basal area of the filaments is white (Figs 23, 24), whereas in *E. a. enastri* the basal area of the filaments is generally pale orange and the filaments arise from an orange patch on the segment (Figs 11, 12). The pupa of *E. a. enastri* is substantially larger, with the brown markings often darker, than that of *E. c. corinna* (Figs 25-27).

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THE COMPLETE LIFE HISTORY OF *CHARAXES LATONA* BUTLER (LEPIDOPTERA: NYMPHALIDAE) FROM CAPE YORK PENINSULA, QUEENSLAND, AUSTRALIA

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Abstract

The complete life history of *Charaxes latona* Butler is described from eggs reared from Iron Range, Cape York Peninsula, Australia.

Introduction

Following its discovery in Australia in 1978 (Johnson and De Baar 1979), *Charaxes latona* Butler, 1865 was recorded breeding on *Cryptocarya triplinervis* and a final instar larva and the pupa were described by Wood (1986). The species occurs throughout Papua New Guinea, where it is recorded breeding on plants in several families (Parsons 1998), but no descriptions have been published of the entire life history. During a trip to Iron Range (Cape York Peninsula, northern Queensland) in November 1991, we observed a female ovipositing on a *C. triplinervis* growing in the bed of the Claudie River; however, the resultant larva died in the second instar during a period of unseasonably hot weather in Townsville. In May 2008, we again observed a female ovipositing twice, approximately 15 metres above the ground in a tree growing along the levee of Gordon Creek. We were able to recover both eggs by using an elevating work platform. They were returned to Townsville and reared on wet cuttings of the plant.

Life history

Food plant. *Cryptocarya triplinervis* R. Br. (Lauraceae).

Egg (Figs 1-2). Hemispherical; diameter 3 mm; flattened apex with slightly depressed smooth central micropyle. Deep yellow when first laid but becoming cream with variable reddish brown dorsal area after 48 hours. Between 24 to 28 fine ridges from micropyle to base.

First instar larva (Fig. 3). Length 4-6 mm. Body dull brownish yellow; thoracic segments slightly darker. Head capsule reddish brown with blackish dorsal and lateral margins and black patches anteriorly. Two pairs of slightly recurved horns; lateral pair reddish brown with white tips and short spines medially; dorsal pair blackish with faint white tips. Posterior segments whitish and produced laterally into backwardly directed curved spines with yellow tips. Body with dorsal and lateral lines of fine white setae.

Second instar larva (Fig. 4). Length 7-10 mm. Head capsule rugose, reddish brown with dorsal area black. Lateral horns red-brown with white tips; dorsal horns black with white tips and short lateral spines and a pair of basal lateral and medial black pointed spines. Prothorax dark red-brown. Remainder of

thoracic and anterior abdominal segments green. Abdominal segment 3 with large white crescent patch dorsally. Dorsolateral lines of faint white spots and lateral and dorsolateral lines of small white setae. Posterior abdominal segments yellowish with terminal segment produced into recurved whitish horns.

Third instar larva (Fig. 5). Length 11-25 mm. Head capsule finely rugose, green with grey or brown margin; eyespots black and mouthparts brown. Pair of recurved pale brown lateral horns with yellow tips. Large black dorsal horns with yellow tips and pointed spines laterally and medially. Short spines with blunt black tips between larger recurved spines. Body green; each segment with dense rows of faint yellow spots. Abdominal segment 3 with large dorsal white crescent patch edged black infused with bright blue flecks. Abdominal segments 5 and 7 with variable dorsolateral white spots edged black with blue flecks. Terminal abdominal segment yellowish orange, produced into inwardly curved, backwardly directed spines and dorsal surface with a small white patch centrally and red-brown triangular areas laterally. Each segment with pairs of short yellow spines forming a lateral line. Prolegs and basal surface whitish.

Fourth instar larva (Fig. 6). Length 26-39 mm. Similar to third instar but developing prominent pink suffusion within white crescent.

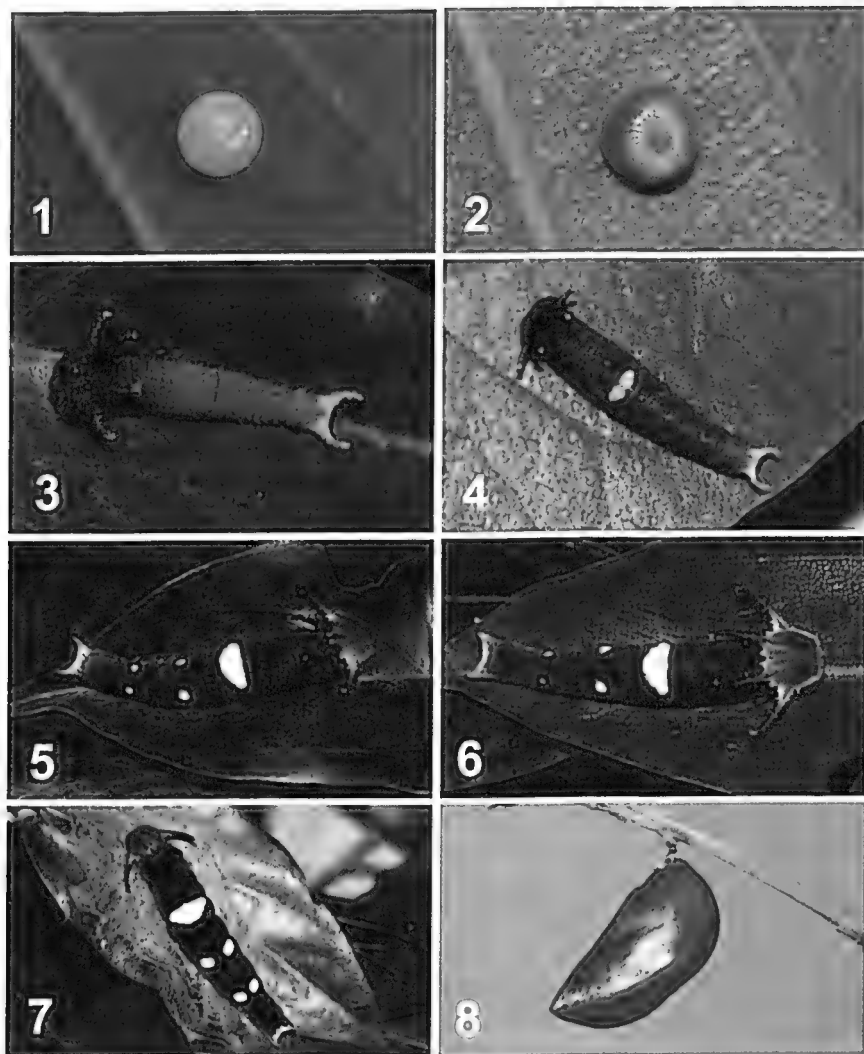
Final instar larva (Fig. 7). Length 40-60 mm. Similar to third instar but terminal segment becoming darker with lateral triangular patches blackish and central white area more extensive. Spiracles white and more prominent.

Pupa (Fig. 8). Length 25 mm. Smooth; dark green. Cremaster black with white globules surrounding anal and genital scars. Variable white areas on wing cases and at distal end.

Observations

The egg recovered in 1991 was laid on the upper surface of the leaf, whereas those laid in 2008 were laid on the undersides of leaves. The newly hatched larva consumed the eggshell. The later instar larvae were similar to the one described by Wood (1986) but a final instar larva from Papua New Guinea, illustrated by Parsons (1998), showed obvious white crescent patches on abdominal segments 3 and 5. It is not known if the additional crescent patch is a consistent difference between Australian and Papua New Guinean populations. The length of the final instar larvae appears consistent with that reported by Parsons (1998) but is substantially larger than the one reared by Wood (1986), even though all produced males. It is possible that female larvae may be larger.

The duration of the stages in Townsville between May and September was as follows: egg 7 days; first instar 6 days; second instar 17-19 days; third instar 16-17 days; fourth instar 14 days; final instar 41-43 days; pupa 18 days.



Figs 1-8. Life history stages of *Charaxes latona*. (1) freshly laid egg; (2) egg after 24 hours; (3) first instar larva; (4) second instar larva; (5) third instar larva; (6) fourth instar larva; (7) fifth instar larva; (8) pupa.

To date, *Cryptocarya triplinervis* is the only plant known to be used by *C. latona* in Australia. In recent years, during studies of the canopy through the Claudie valley, we have commonly observed adult females flying in gaps in the canopy along the levees of the Claudie River and Gordon Creek. *Cryptocarya triplinervis* is a common plant along these levees and the large number of female *C. latona* observed may be a result of the local abundance of the food plant. Further observations would be needed to identify any other food plants in Australia.

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ADDITIONS AND AMENDMENTS TO A RECENT CLASSIFICATION OF *DACUS* FABRICIUS (DIPTERA: TEPHRITIDAE: DACINAE)

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Abstract

Twenty-nine newly described or recognised species of Afrotropical and Indo-Australian *Dacus* Fabricius are placed within a classification proposed for all species. In addition, the Australian species *D. concolor* Drew is placed as a new synonym of *D. (Neodacus) salamander* Drew & Hancock, stat. rev., the African species *D. chrysomphalus* (Bezzi) is transferred from subgenus *Mictodacus* Munro to the *D. (Leptoxyda) eminus* group and the Afrotropical *scaber* group is transferred from subgenus *Psilodacus* Collart to subgenus *Didacus* Collart. *Metidacus* Munro, *Coccinodacus* Munro and *Andriadacus* Munro are placed as new synonyms of *Leptoxyda* Macquart. *Saccodacus* Munro is placed as a new synonym of *Didacus* and the *scaber* group is regarded as a close ally of the Sri Lankan species *D. (Didacus) keiseri* (Hering).

Introduction

Two recent contributions on the classification of the widespread fruit fly genus *Dacus* Fabricius (Hancock and Drew 2006, White 2006) agreed in many respects but differed substantially in others. These differences largely result from the different interpretation of three key features: the geographical centre of origin of the genus, its primitive host plant group and the nature of the yellow marking along the mesonotal suture in the ancestral species. These were regarded, respectively, as Southeast Asia, Asclepiadaceae and broadly connected to the notopleural callus by Hancock and Drew (2006), or as Africa, Cucurbitaceae and an isolated spot by White (2006). Further evidence is needed to determine which (if either) of these sets of assumptions is correct and if the outgroup selections are appropriate. Contrary to White (2006), a broadly connected sutural marking is present in several Indo-Australian species of *Bactrocera* Macquart, in both the *Bactrocera* and *Zeugodacus* groups of subgenera (e.g. *B. (Bactrocera) mendosa* (May), *B. (Asiadacus) brachycera* (Bezzi) [= *fuscans* Wang], *B. (Sinodacus) hochii* (Zia), *B. (S.) binoyi* Drew, *B. (S.) transversa* (Hardy), *B. (S.) perpusilla* (Drew), *B. (Zeugodacus) gavis* (Munro), *B. (Z.) macrovittata* Drew). The sutural marking is also connected in the basal genus *Monacrostichus* Bezzi.

Discussion

With the loss of some species to synonymy (White 2006) and the addition of newly described or recognised taxa from the Afrotropical Region (White 2006) and Bhutan (Drew *et al.* 2007), the number of *Dacus* species now recognised is 249 (177 Afrotropical and 72 Indo-Australian). Incorporation of the new data provided by White (2006) maintained a high degree of stability within the classification of Hancock and Drew (2006), except that biological information requires the transfer of the *scaber* group from subgenus *Psilodacus* Collart to subgenus *Didacus* Collart. In addition, the *D. (Dacus) venetatus* and *D. (Psilodacus) semisphaereus* groups should, on

morphological evidence (White 2006), be combined with the *D. (D.) eclipsis* and *D. (P.) mulgens* groups respectively.

One anomalous species that tests both classifications is *D. chrysomphalus* (Bezzi). Placed in subgenus *Mictodacus* Munro by Hancock and Drew (2006) and in subgenus *Dacus* by White (2006), it has the sutural yellow mark often interrupted medially; hence this character could be interpreted either as united with the notopleuron or isolated. Its host plant has been recorded as *Marsdenia abyssinica* (Asclepiadaceae) (White 2006) and, although this record has not yet been repeated, it is considered to be reliable. This, together with the variable sutural mark, an apically expanded costal band that does not cross vein M and several other morphological characters (e.g. structure of the aedeagus and shape of the surstyli), suggests an affinity with species placed in subgenus *Leptoxyda* Macquart. *D. chrysomphalus* is placed here within the *D. (Leptoxyda) eminus* group; it retains supra-alar setae and three distinct postsutural yellow vittae and keys to couplet 11 in Hancock and Drew (2006). As a consequence of this transfer, recognition of subgenus *Metidacus* Munro (= *Coccinodacus* Munro; = *Andriadacus* Munro) becomes untenable and all three names are regarded here as new synonyms of *Leptoxyda*.

White (2006) noted that four species in the *scaber* group of Hancock and Drew (2006), viz. *D. apostata* (Hering) [= *retextus* (Munro)], *D. triater* Munro, *D. phloginus* (Munro) and *D. rufoscutellatus* (Hering), were bred from the fruit of *Zehneria* (Cucurbitaceae). Thus they cannot remain in subgenus *Psilodacus sensu* Hancock and Drew (2006) which, by definition, includes no cucurbit-feeding species. White (2006) placed the above species, together with *D. nigriscutatus* White, in subgenus *Lophodacus* Collart but they lack the medial vitta on the scutum and breed in fruit rather than the stamens of male flowers, both used as defining characters of *Lophodacus* by Hancock and Drew (2006). They also lack the black face seen in all other *Lophodacus* species except *D. (L.) elegans* (Munro) and are best placed in subgenus *Didacus sensu* Hancock and Drew (2006). The host plant data, lack of lure response and similarity in general appearance (including the small size and lack of an anal streak) suggest a close relationship between the *scaber* group and the Sri Lankan *D. (Didacus) keiseri* (Hering) but the relationships of the Southeast Asian *D. (D.) hainanus* Wang & Zhao remain uncertain. As a result of this transfer, *Saccodacus* Munro (with type species *D. triater*) becomes a new synonym of *Didacus* Collart.

Other species included in the *scaber* group by Hancock and Drew (2006) were retained in subgenus *Psilodacus* by White (2006), but the very similar structure of the male aedeagus (with a centralised apicodorsal rod and large apical membrane) suggests all members of the group belong in *Didacus*; consequently, *D. scaber* Loew, *D. basifasciatus* (Hering) and *D. namibiensis* Hancock & Drew are also transferred. The entirely yellow face and loss of all or most of the microtrichia in cell br above cell bm distinguishes this group.

Table 1. Placement of newly described, misplaced or previously unrecognised species of *Dacus* according to the classification of Hancock and Drew (2006).

As currently listed or recently described	Suggested placement
Indo-Australian taxa	
<i>D. (Mellesis) dorjii</i> Drew & Romig *	<i>D. (Mellesis) siamensis</i> group
<i>D. (Mellesis) fletcheri</i> Drew *	<i>D. (Mellesis) siamensis</i> group
<i>Bactrocera salamander</i> (Drew & Hancock) *	<i>D. (Neodacus) absonifacies</i> group
Afrotropical taxa	
<i>D. (Dacus) apiculatus</i> White *	<i>D. (Dacus) eclipsis</i> group
<i>D. (Dacus) limbipennis</i> Macquart	<i>D. (Dacus) armatus</i> group
<i>D. (Dacus) madagascariensis</i> White *	<i>D. (Dacus) armatus</i> group
<i>D. (Dacus) deltatus</i> White	<i>D. (Dacus) fasciolatus</i> group
<i>D. (Dacus) segunii</i> White *	<i>D. (Dacus) fasciolatus</i> group
<i>D. (Ambitidacus) pulchralis</i> White *	<i>D. (Dacus) fasciolatus</i> group
<i>D. (Ambitidacus) katonae</i> Bezzi	<i>D. (Psilodacus) brevistriga</i> group
<i>D. (Didacus) briani</i> White	<i>D. (Psilodacus) mulgens</i> group
<i>D. (Didacus) congoensis</i> White	<i>D. (Psilodacus) binotatus</i> group
<i>D. (Didacus) fissuratus</i> White	<i>D. (Psilodacus) freidbergi</i> group
<i>D. (Didacus) nairobiensis</i> White	<i>D. (Psilodacus) macer</i> group
<i>D. (Didacus) yemenensis</i> White	<i>D. (Leptoxyda) mirificus</i> group
<i>D. (Didacus) copelandi</i> White	<i>D. (Leptoxyda) eminus</i> group
<i>D. (Didacus) elatus</i> White	<i>D. (Leptoxyda) eminus</i> group
<i>D. (Leptoxyda) kakamega</i> White	<i>D. (Leptoxyda) eminus</i> group
<i>D. (Leptoxyda) mediovittatus</i> White *	<i>D. (Leptoxyda) eminus</i> group
<i>D. (Leptoxyda) nigrolateris</i> White	<i>D. (Leptoxyda) eminus</i> group
<i>D. (Leptoxyda) parvimaculatus</i> White	<i>D. (Leptoxyda) eminus</i> group
<i>D. (Leptoxyda) arabicus</i> White	<i>D. (Leptoxyda) obesus</i> group
<i>D. (Leptoxyda) apectus</i> White	<i>D. (Psilodacus) binotatus</i> group
<i>D. (Leptoxyda) pleuralis</i> Collart	<i>D. (Mictodacus) sphaeristicus</i> group
<i>D. (Lophodacus) nigriscutatus</i> White	<i>D. (Didacus) scaber</i> group
<i>D. (Lophodacus) umehi</i> White	<i>D. (Leptoxyda) umehi</i> group
<i>D. (Mictodacus) chrysomphalus</i> (Bezzi) ¹	<i>D. (Leptoxyda) eminus</i> group
<i>D. (Neodacus) quilicii</i> White *	<i>D. (Neodacus) xanthaspis</i> group
<i>D. (Psilodacus) gabonensis</i> White	<i>D. (Dacus) purus</i> group
<i>D. (Psilodacus) merzi</i> White	<i>D. (Dacus) purus</i> group
<i>D. (Psilodacus) okumuae</i> White ²	<i>D. (Didacus) ciliatus</i> group
<i>D. (Psilodacus) scaber</i> group ³	<i>D. (Didacus) scaber</i> group

* = collected in cue-lure traps; ¹ = bred from fruit of *Marsdenia* (Asclepiadaceae); ² = bred from fruit of *Gerrardanthus* (Cucurbitaceae); ³ = bred from fruit of *Zehneria* (Cucurbitaceae).

The Australian *Dacus* (*Neodacus*) *salamander* Drew & Hancock, stat. rev. (= *concolor* Drew, syn. n.) has fused abdominal tergites and a very weak supernumerary lobe on the wing. Accordingly, it is transferred from

Bactrocera (*Sinodacus*) Zia to the *D. (N.) absonifacies* group. The postpronotal lobes are either entirely yellow or anteriorly darkened and the medial postsutural yellow vitta is a little variable in shape.

The 29 nominal species recently recognised or described by White (2006) and Drew *et al.* (2007), plus the misplaced taxa discussed above, are listed in Table 1, together with an indication of where they belong according to the system of Hancock and Drew (2006). Several synonyms were proposed by White (2006) but, apart from *D. (Mictodacus) tubatus* Munro (now regarded as a synonym of *D. (Leptoxyda) aspilus* Bezzi), their subgeneric placements remain unchanged. Species transferred here from subgenus *Didacus* to subgenus *Leptoxyda* appear to belong in either the *D. (L.) mirificus* group (*D. yemenensis* White, which has fuscous costal cells and a reduced anal stripe), or the *D. (L.) minus* group, close to *D. carnesi* (Munro) (with fulvous costal cells and a distinct anal stripe). *D. umehi* White was included provisionally in *Lophodacus* by White (2006); however, the presence of a slender medial vitta plus a distinct anal stripe and no pecten suggest it is best placed as a monotypic group within *Leptoxyda*, close to the *herensis* group.

In Hancock and Drew (2006: Appendix 2), character 32 for *D. (Mellesis) pedunculatus* (Bezzi) and *D. (Didacus) apostata* (Hering) should read '0' [pecten present], not '2'; characters 25-27 for *D. (Didacus) namibiensis* should read '222', not '333'; character 3 for *D. (Leptoxyda) externellus* (Munro) should read '0' [anterior notopleural seta present], not '1'; character 3 for *D. (Psilodacus) elutissimus* Bezzi should read '1' [anterior notopleural seta absent], not '0'; and characters for *D. (P.) semisphaereus* Becker should read '0110 3-300 02022 11110 20100 0020? 600'. In White (2006: cd-rom file D2), the record of *D. scaber* from 'Kilimanjaro' probably refers to a farm in South Africa, not Mt Kilimanjaro in Tanzania, whereas the record of '*D. humeralis*' from Mackay, Q[ueensland] refers to *Bactrocera neohumeralis* (Hardy), a replacement name for '*Dacus*' *humeralis* Perkins, not Bezzi.

Acknowledgements

I thank Kerrie Huxham and Sally Cowan (AQIS, Cairns) for initially recognising the apparent *D. salamander*/*D. concolor* synonymy and bringing it to my attention, and Prof. R. Drew (Griffith University) for confirming it.

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A COMPARISON OF THE IMMATURE STAGES OF *HYPOCHRYSOPS APOLLO APOLLO* MISKIN AND *H. A. PHOEBUS* (WATERHOUSE) (LEPIDOPTERA: LYCAENIDAE)

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Abstract

The immature stages and some life history details are described for the two subspecies of *Hypochrysops apollo* Miskin that occur in Australia. Eggs of *H. a. apollo* and *H. a. phoebus* (Waterhouse) were of similar size but those of *H. a. apollo* were pitted but otherwise smooth whereas eggs of *H. a. phoebus* had conspicuous ridges and spines. First and second instar larvae had the same basic patterns of setae but the setae of *H. a. apollo* were much shorter and more thickened or flattened than those of *H. a. phoebus*. First instars also differed in the development of some of the glandular structures on the body. Larvae of both subspecies passed through at least eight instars before pupation under artificial rearing conditions. There were differences in oviposition site between subspecies, with eggs of *H. a. apollo* being laid closer to the leaves of the food plant, and in first-instar duration, with larvae of *H. a. phoebus* moulting sooner to the second instar, but these life history differences were confounded with differences in food plants and rearing occasions.

Introduction

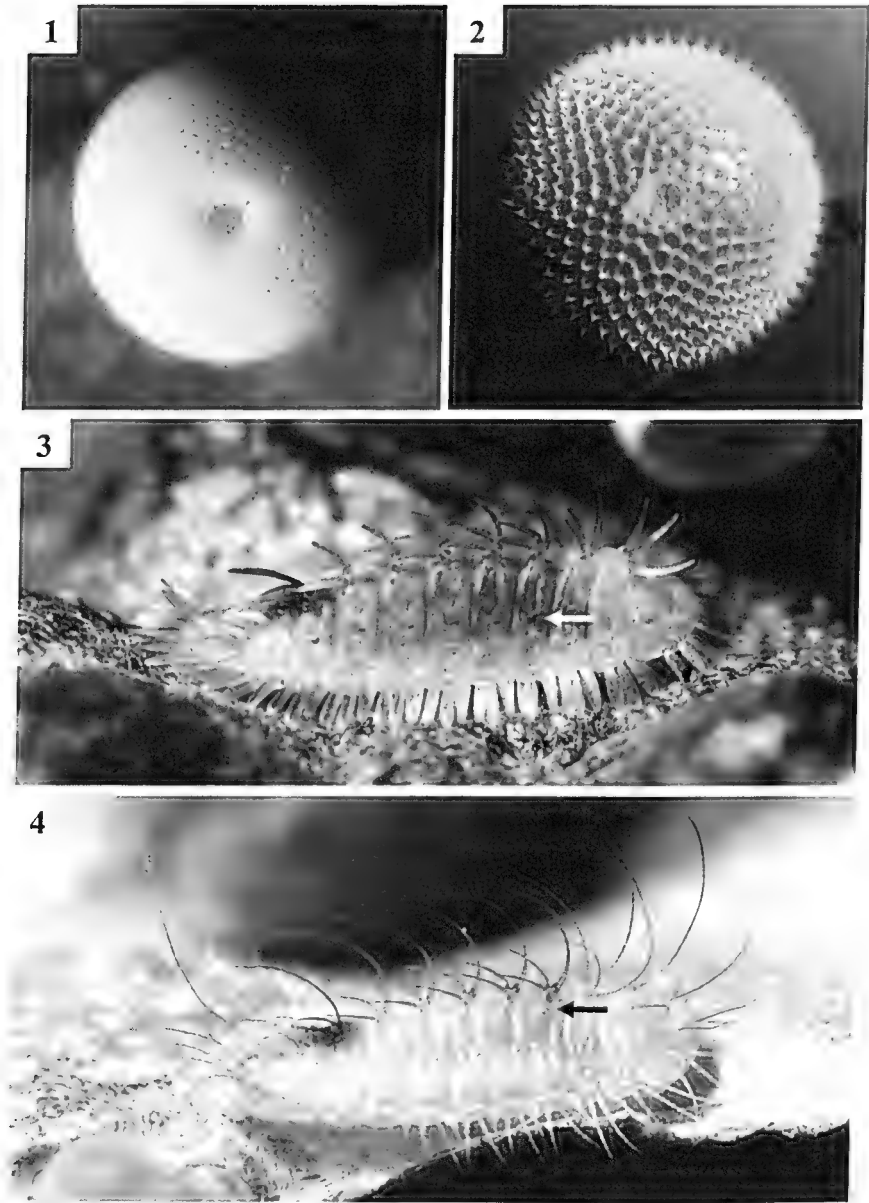
Hypochrysops apollo Miskin includes three subspecies, two of which occur in Australia: *H. a. apollo*, distributed from Cooktown to Ingham, and *H. a. phoebus* (Waterhouse), found north from the Rocky River in central Cape York Peninsula to Papua New Guinea (Braby 2000). Adults can be distinguished by colour and wing shape (Braby 2000).

Some aspects of the life history of *H. apollo* in Australia are well known and were summarised by Braby (2000). Larvae feed on species of ant-plant (Rubiaceae), including *Myrmecodia beccarii* in the southern parts of the range (*H. a. apollo*) and *M. tuberosa* in far northern Queensland (*H. a. phoebus*). Eggs are laid singly on the foodplant. Larvae live in the galleries that occur naturally within the plant stems and tubers and cohabit with ants, usually *Philidris cordatus stewartii* (Forel), which colonise the same galleries in large numbers. The larvae feed on the internal tissues of the plant and sometimes also on the leaves at night. Pupation occurs within the enlarged galleries inside the plant, the pupa being attached by anal hooks and a central girdle. The adult emerges through a hole made previously by the larva.

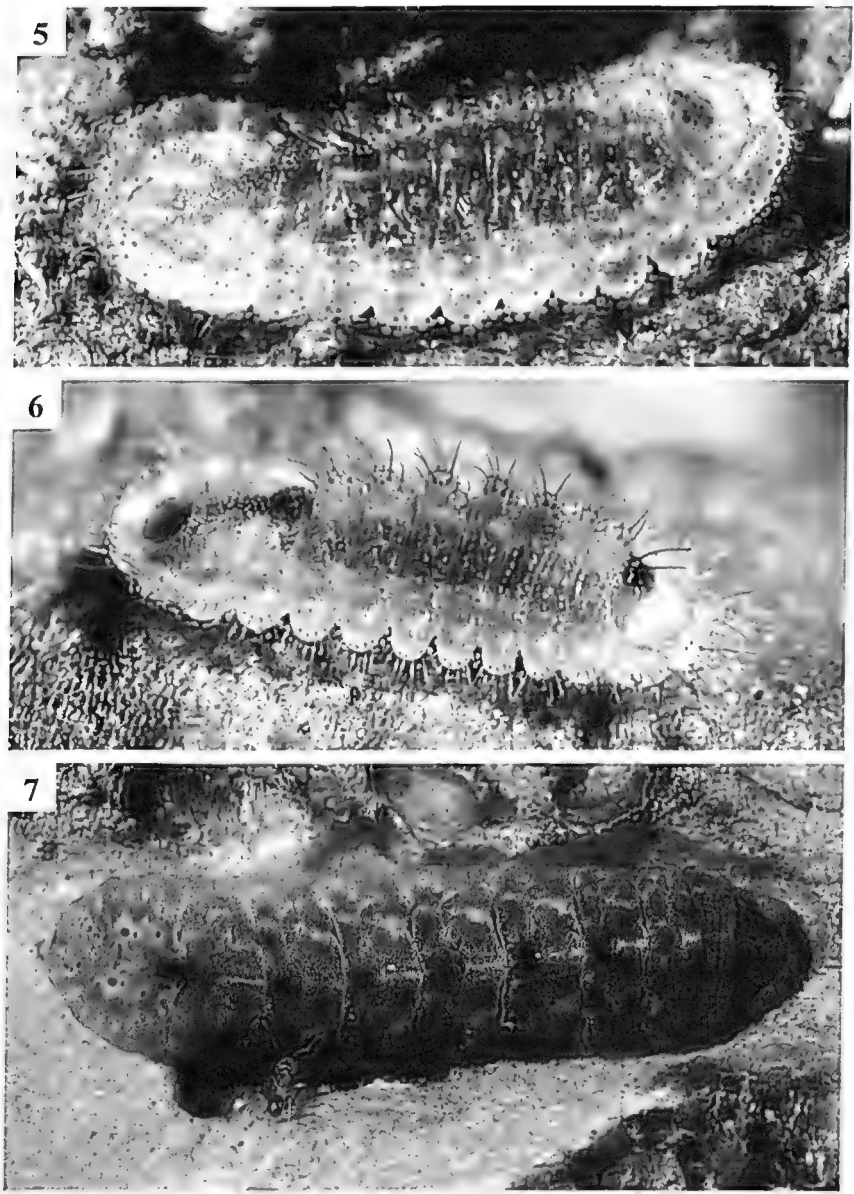
Braby (2000) gave a general description of large larvae and pupae without reference to subspecies and noted that the egg was not described. Here I describe the early stages of both Australian subspecies, with additional notes on their life histories, and document significant differences between them.

General descriptions for both subspecies

Egg (Figs 1-2). Diameter 1.2-1.3 mm. A flattened sphere with sunken micropyle, sculptured with pits or with ridges and spines depending on subspecies; pale green or bluish green soon after oviposition.



Figs 1-4. *Hypochrysops apollo*. (1-2) eggs: (1) *H. a. apollo*; (2) *H. a. phoebus*. (3-4) first instar larvae: (3) *H. a. apollo*; (4) *H. a. phoebus*. Conspicuous glands on A1 of first instar are indicated by arrows.



Figs 5-7. *Hypochrysops apollo*. (5-6) second instar larvae: (5) *H. a. apollo*; (6) *H. a. phoebus*. (7) *H. a. phoebus*, final instar larva.

First instar larva (Figs 3-4). Flattened with dorsal ridge and with middorsal tubercles on mesothorax (T2) to abdominal segment 5 (A5); four pairs of brown anterior setae on T1, two pairs on margin and two pairs slightly posterior to margin; T2-T3 each with two pairs of similar erect pale brown dorsal setae; A1-A6 each with two pairs of dorsal setae, pale brown on A1-A5 and dark brown on A6; numerous reclining setae on anal segments, the ultimate pair longer and curved upwards; three pairs of lateral setae on each of T1-A7; six pairs of posterior setae; fine ventrolateral setae, one pair per segment; body greyish, green or yellowish green, a reddish brown dorsal patch on A6-A7, sometimes with a reddish brown middorsal line on A1-A5, head pale brown. One pair of conspicuous circular epidermal structures (presumably glands) subdorsally or dorsolaterally on A1, subdorsally towards rear of each of A2-A5, dorsolaterally on A6 and dorsally on anal segments.

Second instar larva (Figs 5-6). Flattened with dorsal ridge and with middorsal tubercles on T2-A6; lateral margin deeply scalloped; T1 with three setae, one pair subdorsal and a single median seta, from rear of prothoracic plate; T2- or T3-A5 with short brown dorsal setae; tiny trumpet-shaped setae on dorsal tubercles; trumpet-shaped or fine marginal setae; short fine ventrolateral setae beneath scalloped margin; body greyish, darker dorsally, sometimes with reddish dorsolateral mottling and white subdorsal line, a reddish middorsal line on A1-A7, reddish lateral spots; prothoracic and anal plates glossy; head pale brown. Tentacular organs (TOs) present.

Third instar larva. Flattened with dorsal ridge and with middorsal tubercles on T2-A6; lateral margin deeply scalloped; one or two pairs of short dorsal setae on T2-A5 or -A6; numerous tiny trumpet-shaped setae; greyish, pinkish dorsally and dorsolaterally with cream lines subdorsally on T2-A5 and dorsolaterally and laterally on T2-A6, sometimes with reddish lateral line; prothoracic plate dark brown, anal plate pale brown with dark brown median and lateral patches anteriorly, TOs brown, spiracles dark brown. Newcomer's organ (NO) and TOs present.

Final instar larva (Fig. 7). Mottled pinkish brown and greyish cream, a broken white middorsal line with a posterior dark pinkish brown middorsal patch on each of T3-A6, an anterior dark pinkish brown patch on A7, a wavy greyish dorsolateral line and cream lateral line; prothoracic plate with dark brown spots dorsolaterally and on posterior margin, anal plate sunken, pinkish with dark brown dorsolateral spots and sometimes with an anterior 'V'-shaped marking, TOs brown, head brown.

Pupa. Pale brown, sometimes with reddish brown abdomen, speckled with dark brown; attached by anal hooks and central girdle.

Morphological differences between subspecies

The major differences between the immature stages of *H. a. apollo* and *H. a. phoebus* are listed in Table 1. These notes expand on the common details

given in the previous section. Eggs and larvae are clearly distinguishable until at least the third larval instar. Eggs of *H. a. apollo* have much reduced surface sculpturing, while early instar larvae have setae that are flattened or thickened and much reduced in length. Late instar larvae and pupae of the two subspecies are similar, although larvae of *H. a. phoebus* tend to be more strongly marked with darker spiracles.

Table 1. Morphological differences between the immature stages of *Hypochrysops apollo apollo* and *H. a. phoebus*.

Stage	Character	<i>H. a. apollo</i>	<i>H. a. phoebus</i>
Egg	Sculpturing	Tiny pits in oblique rows, without ridges or spines.	Fine oblique ridges forming four-sided cells, with short spines at their intersection.
First instar	Anterior setae	Flattened (on margin) or thickened (posterior to margin).	Fine.
	Dorsal setae	On T2-T3 thick; on A1-A6 thick, inner anterior pair erect, outer posterior pair broad basally and reclining.	On T2-T3 long, fine; on A1-A6 fine, inner anterior pair long and outer posterior pair shorter; ultimate posterior pair on anal segments very long.
	Lateral setae	Flattened, pale greenish brown.	Long, fine, branched, the anterior pair on A1-A7 basally flattened; pale brown.
	Posterior setae	Five pairs flattened, posterior median pair thin.	Long, fine, posterior median pair shorter.
	Conspicuous epidermal glands	Dorsolateral on A1; all glands similar in size.	Subdorsal on A1, subdorsal glands on A2-A5 smaller than others.
Second instar	Dorsal setae	On T1 tiny, trumpet-shaped with expanded tips; on T3-A5 thick.	On T1-A5 fine.
	Fine marginal setae	Absent.	Numerous.
	Prothoracic plate	Uniform colour.	Dark brown dorsal patch posteriorly.
Third instar	Dorsal setae	Club-shaped, absent from A6.	Fine.

Life history notes

Hypochrysops a. apollo

I observed or collected immature stages of this subspecies on *Myrmecodia beccarii* attached to mangroves east of Innisfail, northern Queensland. Unhatched eggs were present on 5 November 2003, 26 March 2004 and 1-3 November 2005. I found a total of 36 eggs, 13 unhatched and 23 hatched and, of these, 19 were attached to small tubers, less than about 5 cm diameter, which often grew at the base of larger plants. Sixteen eggs were attached to leaves and 19 were close to a leaf base on stems or small tubers. Only one egg was found on a large tuber distant from the leaves.

A first instar larva was found on 5 November 2003, on young leaves on a small tuber of 2-3 cm diameter, with a hatched egg on the tuber. The larva had been feeding on the very youngest leaf on the plant. First instars that emerged in captivity also ate young leaves, chewing tiny circular holes or eating scallops from the margins. Many continued feeding exposed on young leaves throughout the instar but one, having fed on leaves for a day, entered into a small tuber via one of the tuber openings and was subsequently found inside the tuber as a second instar. First instars were seen to be palpated by ants on occasions but were often unattended. Large larvae in captivity were supplied small pieces of tuber and leaves and fed on both.

Days to hatching of 11 eggs collected in November ranged up to 7 (two eggs), 8 (one egg) and 9 (one egg). Mean duration of the first instar was 5 days (4-6 days, $n = 7$). Only one larva was reared from egg to pupa, with a larval duration of 111 days. The number of instars that this larva passed through is uncertain, as at least one moult was not observed but, by interpolation of expected instar durations, is believed to have been 10 or 11.

Hypochrysops a. phoebus

I observed or collected immature stages of *H. a. phoebus* from 24-29 May 2005 at two sites, near Punsand Bay and at Iron Range, Cape York Peninsula. Food plants are believed to have been two species of *Myrmecodia*, *M. platytyrea* near Punsand Bay and *M. platytyrea* and *M. tuberosa* near Iron Range, based on their distributions and descriptions given in Huxley and Jebb (1993), and a third very different ant-plant, consistent with *Hydnophytum moseleyanum* (= *H. papuanum*) as illustrated by Williams (1987), in both areas. However, no plants were collected for positive identification.

Of 14 unhatched eggs found on *Myrmecodia* spp., two were on the swollen tuber base and the remainder were on the thick stems, often attached to spines. Many hatched eggs were also found on *Myrmecodia* stems and tubers. No eggs were found on the leaves. A hatched egg was also found near Punsand Bay on the ant-plant tentatively identified as *H. moseleyanum*, attached to a spine on the swollen tuber near the point of attachment of the multiple stems.

First instar larvae, when placed on a piece of *Myrmecodia* stem, ate tiny holes in the fleshy green 'spines' around the rim of the shield-shaped structures (clypeoli) surrounding each leaf base. However, feeding was minimal and the duration of the stage was short (see below). Ants confined with the larvae were not observed to interact with them at all. Large larvae ate both the pieces of tuber and the leaves that were supplied as food.

Individuals collected as eggs in May were kept at ambient temperature in far northern Queensland until mid-way through the second instar, when they were transferred to a constant 26°C. The longest time to hatching of 11 eggs was 7 days (three eggs). All first instars moulted to the second in 3 days ($n = 9$). Three larvae were reared from egg to pupa, with durations of 72 days (eight larval instars, male), 88 days (nine larval instars, female) and 89 days (nine larval instars, died as pupa). The pupal stage occupied 15 and 17 days for the two pupae that successfully produced adults.

Discussion

Larvae of *H. apollo* passed through at least eight larval instars; more than is usual for most lycaenid larvae. However, larvae of two other species of *Hypochrysops* C. & R. Felder, *H. hippuris nebulosis* Sands and *H. elgneri barnardi* Waterhouse, have been recorded as passing through six and seven larval instars, respectively (Samson 2002). Larvae of *Paralucia aurifera* (Blanchard), in a related genus within the tribe Luciini, passed through five or six instars if ants were present and six or seven instars if ants were absent (Cushman *et al.* 1994). I reared larvae of *H. apollo* without ants and the food supplied to the larva of *H. a. apollo* in particular was occasionally of poor quality; these factors could have led to an increase in the number of instars (Cushman *et al.* 1994, Esperk *et al.* 2007).

Although the basic morphology of the early immature stages of *H. a. apollo* and *H. a. phoebus* was similar, there were some marked differences. Eggs were of similar size but those of *H. a. apollo* were pitted, whereas eggs of *H. a. phoebus* had conspicuous ridges and spines. First and second instars had the same basic patterns of setae but the setae of *H. a. apollo* were much shorter and thickened or flattened, a difference which was still apparent but less pronounced in the third instar. First instars also differed in the development of some of the glandular structures on the body. Differences between the subspecies were less obvious in later instars and final instar larvae appeared morphologically similar.

I also recorded differences in oviposition site and first instar biology, but these were confounded with differences in host plants and time of year. According to the recorded distributions of *Myrmecodia* spp., *M. beccarii* is the predominant species within the range of *H. a. apollo*, although *M. platytyrea* is also found near Daintree and Mossman; *M. beccarii* does not occur within the range of *H. a. phoebus* (Huxley and Jebb 1993, P.I. Forster pers. comm.). I found eggs of *H. a. apollo* mainly on or near young leaves of

M. beccarii, often on juvenile plants, whereas most eggs of *H. a. phoebus* were found on tubers or tuber stems. First instar larvae of *H. a. phoebus* fed sparingly in captivity and moulted to the second instar sooner than larvae of *H. a. apollo*. Simultaneous rearing of both subspecies on the same food plant would be needed to see if these differences are real.

Eggs and early instar larvae of *H. a. phoebus* from Punsand Bay (10°44'S) and Iron Range (12°44'S) were similar, these sites being near the northern and southern limits of the subspecies' range on the Australian mainland (Cape York to the Rocky River: Braby 2000). Although the above descriptions of the immature stages of *H. a. apollo* are all based on specimens from near Innisfail (17°30'S), an egg I collected previously at Cooktown (15°32'S), at the northern limit of this subspecies' range, was noted to have been pitted and without spines, while the first instar that emerged had short, flattened setae similar to those described above (PRS unpubl. notes). Thus, there is reason to believe that the descriptions recorded above are generally applicable to populations referred to either *H. a. apollo* or *H. a. phoebus* on the Australian mainland. *H. a. phoebus* also occurs on islands in the Torres Strait and in Papua New Guinea (Braby 2000), but no immature specimens have been examined from these localities. It would be of interest to examine these and also to determine if *H. apollo* occurs on the east coast between Silver Plains (13°46'S, near the Rocky River) and Cooktown, an area from which there are also no voucher specimens of ant-plants in the Queensland Herbarium (although there is at least one unvouchered record of *M. beccarii* from Starcke, 15°04'S: P.I. Forster pers. comm.).

The marked differences reported above support the taxonomic separation of *H. a. apollo* and *H. a. phoebus* to at least subspecific level and raise the possibility that they might not be conspecific.

Acknowledgements

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SCROBIGER SPLENDIDUS (NEWMAN) (COLEOPTERA: CLERIDAE) ASSOCIATED WITH HYLAEUS SP. (HYMENOPTERA: COLLETIDAE) IN SOUTHEASTERN QUEENSLAND

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Abstract

Scrobiger splendidus (Newman) was observed ovipositing on, and emerging from, the nest of a native bee (*Hylaeus* sp.) at Indooroopilly, SE Queensland. Based on published accounts of a North American clerid exhibiting similar behaviour, it is likely that *S. splendidus* is a predator of *Hylaeus* spp. in Australia. This is the first evidence of apivorous habits for a native Australian clerid beetle.

Introduction

Cleridae are a cosmopolitan family of mostly predatory beetles containing over 3,600 species in roughly 300 genera (Gerstmeier 2000). While clerids are perhaps most well known as predators of lignicolous insects within timber and under bark, the prey range of the family is much broader and includes locust eggs, gall insects, psyllids and aculeate Hymenoptera (Eliason and Potter 2000, Linsley and MacSwain 1943, New 1978). This paper deals with the predation of bees (Apoidea) by clerids.

Records of apivory among northern hemisphere Cleridae include: European *Trichodes* Herbst (Clerinae) preying upon Anthophoridae, Megachilidae and Apidae (*Ceratina* spp. and *Apis mellifera* Linnaeus); North American *Trichodes* preying upon Megachilidae and *Ceratina* Latreille; and the North American genus *Lecontella* Wolcott & Chapin (Tillinae) preying upon Megachilidae (Linsley and MacSwain 1943, Mawdsley 2002). Apivory by Australian Cleridae has not been reported previously.

Apivorous Cleridae employ one of two strategies to ensure that their larvae gain access to the immature bees on which they feed. The first involves the oviposition of a single egg on a flower from where the 'phoretic' early instar larva is collected by a foraging bee, taken to the nest and sealed within a larval cell where it feeds upon both pollen and bee larvae (Linsley and MacSwain 1943). The second strategy involves oviposition directly on or in the nest, as *Trichodes ornatus* Say was observed to do on the artificial nesting boards of *Megachile pacifica* (Fabricius), a bee commonly employed to aid pollination of commercial alfalfa in North America (Davies *et al.* 1979).

The above records indicate that apivorous clerid beetles have the potential to attain pest status. This was certainly true for *T. ornatus* which, prior to the development of an effective bait (Davies *et al.* 1983), was capable of severely reducing the pollinating capacity of commercially employed populations of *M. pacifica*, the economic impact of which was estimated at US\$6 million for the US state of Washington alone in 1977 (Davies *et al.* 1979).



Fig. 1. *Scrobiger splendidus* adult male habitus (length = 9 mm).

Material

Native bees were observed nesting in the corrugations of a large cardboard box situated among insect breeding cages and other debris on a semi-open deck adjoining the Queensland Forestry Sciences laboratory, Indooroopilly, Queensland, in early November 1995 by M. De Baar (pers. comm.) who, after repeated observations, also found clerids at the nesting sites of the bees. Specimens collected from this nest included a native colletid bee and a gasteruptiid bee parasite, respectively determined as species of *Hylaeus* Fabricius (Colletidae) and *Gasteruption* Linnaeus (Gasteruptionidae) by I.D. Naumann, plus four adult clerids determined by the present author as *Scrobiger splendidus* (Newman) (Fig. 1). Label data associated with the specimens are as follows: 'Long Pocket, SE Qld, 3.xi.1995, M. De Baar; large clerids ovipositing on, and small ones emerging from, bee nest in corrugated cardboard'. Specimens are held in the Queensland Forestry Insect Collection (QFIC) and in the collection of the author (JSBC).

The genus *Scrobiger*

According to Corporaal (1950), *Scrobiger* Spinola contains four Australian and one New Caledonian species; however, cursory examination of type specimens of all five species suggests synonymies that may reduce the genus to three valid Australian species (J. Bartlett unpublished). Adults range from approximately 8 mm to 16 mm in length. Larval and adult *Scrobiger* are apparently predaceous on cerambycid beetle larvae (McKeown 1938). During my own field collecting, I observed that these beetles are fast moving, volant, diurnal flower-visiting predators with similar wasp-mimicking behaviour to that of another Australian clerid, *Trogodendron fasciculatum* (Schreibers) (Faithful 1994). *Scrobiger splendidus* has been collected from flowers of the myrtaceous genera *Eucalyptus* (Brooks 1969, Wainer 1979), *Angophora* (Hawkeswood 1981), *Leptospermum* (Matthews 1992) and *Melaleuca* (specimen in author's collection), plus *Euroschinus* (Anacardiaceae) (specimen in Australian Museum, Sydney) and *Xanthorrhoea* (Xanthorrhoeaceae) (specimen in South Australian Museum, Adelaide).

Discussion

Despite no larvae being collected directly from the nest, the above observations indicate a likely association between *S. splendidus* and the *Hylaeus* sp. analogous to that of *T. ornatus* and *M. pacifica* in North America. In both cases the bees were nesting within artificial substrates (corrugated cardboard and commercial nesting boards respectively) that were possibly more exposed than a natural nest, hence allowing greater accessibility to predators. A more exposed nest may simply represent a 'shortcut' for a predator that may instinctively oviposit in the vicinity of bees, or on flowers visited by bees as in the case of *Trichodes*. Additionally, all aforementioned plant genera visited by *S. splendidus*, with the exception of *Euroschinus*, are also among those utilised by *Hylaeus* and other closely

related colletids as pollen and nectar sources (Armstrong 1979). The floral associations shared between *Scrobiger* and *Hylaeus* suggest the possibility that a predator/prey relationship could also exist between them via the first mentioned oviposition strategy (*i.e.* ovipositing directly onto flowers).

According to the Australian Native Bee Research Centre (ANBRC 2006a, b), the profile of Australian native bees as a sustainable alternative to *Apis mellifera* for honey production and crop pollination has, in recent years, grown among backyard gardeners, cottage industry honey producers and progressive horticulturalists. Such a trend must naturally drive a need for increased knowledge of pathogens, diseases and predators of the native Australian apifauna. Regardless of whether *Hylaeus* spp., specifically, are of commercial interest or not, there is evidence that *Scrobiger* contains species that are likely predators of native bees in Australia. Yet it remains unclear whether *Scrobiger* are specialist bee predators in the manner of *Trichodes* and *Lecontella*, or are merely opportunists, exploiting the inhabitants of the artificial nest. Discovery of *S. splendidus* eggs or immature stages would help to clarify the specific nature of this association.

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ADDITIONS TO A RECENT CHECKLIST OF THE FRUIT FLIES (DIPTERA: TEPHRITIDAE) OF NEW CALEDONIA

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Abstract

Euphranta marina Permkam & Hancock, *Philophylla millei* Han & Norrbom and *Oedaspis ouinensis* Hancock are added to the most recent list of New Caledonian fruit flies.

Introduction

Twenty-seven named species of Tephritidae (fruit flies) were recorded from New Caledonia by Mille (2008). This note records a further three species that were either unnamed at the time or are newly recorded from the country.

Additions to New Caledonia species list

Euphranta marina Permkam & Hancock

Material examined. NEW CALEDONIA: 3 ♂♂, 3 ♀♀, Bourail Poé [Beach], (Creek Salé), 21°36'12.90"S, 165°22'24.80"E, 26.ii.-2.iii.2008, S. Cazères, bred ex *Avicennia marina* (in SRFP, La Foa).

Comments. Described by Permkam and Hancock (1995) from coastal areas of northern and eastern Australia, this mangrove-breeding species is known also from southern Papua New Guinea. It is newly recorded from New Caledonia.

Philophylla millei Han & Norrbom

Comments. This species was described from the Sarraméa district by Han and Norrbom (2008). It was previously reported as '*Anastrephoides* sp.' by Norrbom and Hancock (2004) and Mille (2008).

Oedaspis ouinensis Hancock

Comments. This species was described from Mount Ouin by Hancock (2008). It was previously reported as '*Oedaspis* sp.' by Mille (2008).

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**ZELOTYPYA STACYI SCOTT (LEPIDOPTERA: HEPIALIDAE)
– A CONSERVATION PERSPECTIVE**

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Abstract

The status of *Zelotypia stacyi* Scott in Queensland is examined and its apparent rarity reviewed. Additional biological notes are included.

Introduction

The bentwing swift moth, *Zelotypia stacyi* Scott (Fig. 1), is the largest Australian hepialid, with adult female wingspans stated to approach 200 mm (Froggatt 1923), 225 mm (McKeown 1942) or 250 mm (Common 1990). The last recorded New South Wales specimen is believed to have been collected in 1966 (Chadwick 1983). In Queensland six specimens are known from literature (Chadwick 1983, Anonymous 1985). Four of these were collected over a hundred years ago, the remaining two more recently by the authors and Judy Grimshaw. This would suggest extreme rarity. However, almost 20 more specimens are known to have been collected during a four year period from 1978, in the Main Range area of southern Queensland (Hoffmans Falls at Gambubal and Mt Develin: Chadwick 1990, D. Lane pers. comm.). In central New South Wales, more unpublished collections occurred in the 1990s (C. Pratt pers. comm.).

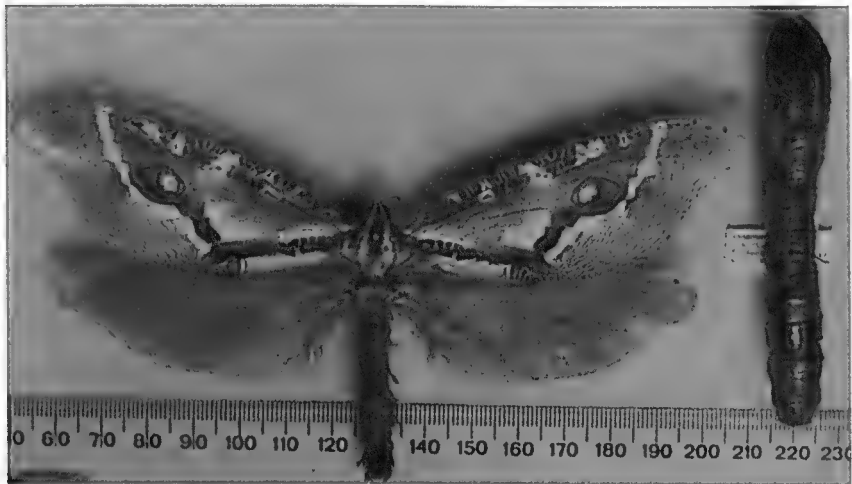


Fig. 1. *Zelotypia stacyi* adult male and exuvium (pupal shell) collected near Goomburra, Queensland.

Discussion

A male of *Z. stacyi*, with a wingspan of 160 mm, was collected near Goomburra, Queensland by M. Hockey and M. De Baar on 21 March 1985 (Fig. 1). On a subsequent field trip to the same site on 1 April 1985, the authors extracted a large larva measuring 70 mm and a pupal exuvium measuring 88 mm from the trunks of *Eucalyptus tereticornis*; numerous exit holes were noted. A pupal shell (damaged but measuring about 70 mm) was extracted from a small *Eucalyptus tereticornis* (Myrtaceae) at Gambubal, near Warwick, on 9 August 1985, again by M. Hockey and M. De Baar. We have also noted exit holes east of Cunningham's Gap in southern Queensland, along the old Cunningham's Gap road.

Tree trunk exit holes indicate that *Z. stacyi* is not as rare as has been assumed. Based on the number of exit holes present in southern Queensland habitats between Goomburra and Gambubal, it is surprising that specimens are not seen more frequently. The larvae bore in branch stems and trunks, mainly of *Eucalyptus tereticornis*, *E. grandis* and *E. saligna*, and may approach 130 mm in length. Froggatt (1923) noted that grey gums, *Eucalyptus punctata*, were attacked in the Gosford district of New South Wales. Olliff (1887) recorded one larva, bred to an adult, from 'black apple tree' [believed to be *Achras australis*, now *Planchonella australis* (Sapotaceae)]. Larvae have also been recorded occasionally damaging young trees of *Eucalyptus grandis* grown for paper pulp in northern New South Wales (Common 1990). According to the New South Wales Forest Commission, *Z. stacyi* is listed among 'the most damaging insects in eucalypt forests' (Stone 1991).

Larval duration is probably at least three years, but possibly up to six years (Froggatt 1923, Chadwick 1990). Adults have a limited emergence period, mainly occurring between February and April, which is probably dependent on specific weather conditions. Froggatt (1923) stated that larvae pupating in December will emerge in March and the pupa is very active days before emergence, pushing out the protective wad. Emergences generally occurred around 3 pm [1500 h] during March in the Newcastle district of New South Wales (Froggatt 1907). Chadwick (1990) summarised various authors' statements about the late afternoon timing of emergences. Middleton (1941) stated that emergences are almost always from 3.30-5.30 pm [1530-1730 h]. Adults are very secretive, are seldom observed and appear reluctant to fly to light traps.

Our observations in the Goomburra and Mt Develin areas (Main Range, southern Queensland) indicate that black cockatoos (Psittacidae: *Calyptrorhynchus* spp.) rip open *Z. stacyi* tunnels, causing some destruction in localised patches, when populations of the moth are most active. Middleton (1941) also noted that black cockatoos are destructive to immatures of this moth.

Zelotypia stacyi has been collected northwards from Cambewarra Mt north of Nowra (Middleton 1941), the Newcastle district (Froggatt 1923), Gosford, Taree, Tyringham via Dorriggo (Middleton 1941) and Tooloom Scrub [noted in E.J. Dumigan collection] in New South Wales and from the Main Range area from Goomburra to Gambubal (Anonymous 1985, M. Hockey and M. De Baar collection data, D. Lane pers. comm.) in southeastern Queensland. The type locality is Chatham near Manning R. and Taree, New South Wales (Scott 1869). A female specimen, with a wingspan of 230 mm, was collected at Binna Burra in the McPherson Range, SE Queensland on 10 March 1997, after a period of rain (G.B. Monteith pers. comm.).

After observations over many field trips, we noted that larval-activity areas shift over the larger region, thus giving a perception of population crashes if research is maintained in a small area. This suggests that large areas of untouched forest are needed to maintain healthy *Z. stacyi* populations, as is the case in southern Queensland along the border ranges through to the Main Range. Almost the entire area of the Queensland distribution of *Z. stacyi* lies within large tracts of connecting State Forests and National Parks along the border ranges and the Main Range, thus providing a relatively safe haven in that State. However, this could be a threatening factor in some New South Wales localities. The phenomenon of larval-activity area-shifts over the larger region has been noted for another hepialid, *Aenetus mirabilis* Rothschild, in northern Queensland by David Lane (pers. comm.).

More research is required before conclusions can be made about this moth and its rarity. However, because larvae are trunk and occasionally branch borers and adults are short lived and seldom observed, only occasionally flying to weak light and emerging in the late afternoon during rain events and mainly only during two or three months, research projects are consequently difficult.

Acknowledgements

We wish to thank Geoff Monteith for *Z. stacyi* information from Binna Burra and for reviewing the manuscript, and David Lane for discussions and specimen label data.

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BUFFEL GRASS (*CENCHRUS CILIARIS* L.) IS A HOST FOR THE SUGARCANE WHITEFLY *NEOMASKELLIA BERGII* (SIGNORET) (HEMIPTERA: ALEYRODIDAE) IN CENTRAL AUSTRALIA

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Abstract

Buffel grass (*Cenchrus ciliaris* L.) is an introduced pasture plant that occurs over much of central Australia. The effects of buffel grass on invertebrate diversity in Australia are largely unknown. The sugarcane whitefly, *Neomaskellia bergii* (Signoret), was discovered infesting buffel grass at several sites in Alice Springs during May and June 2008. The current study is the first record of *N. bergii* in central Australia and the first time that buffel grass has been recorded as a host plant for this species in this country.

Introduction

Buffel grass (*Cenchrus ciliaris* L.) (Poaceae) is a pasture plant native to Africa, southern parts of Asia and India (Lazarides *et al.* 1997). Although knowledge of the entry of this species into Australia is incomplete, what is established is its accidental introduction into northwestern Western Australia in the 1870s (Marriott 1955). This was followed by deliberate sowing throughout Queensland and New South Wales from the 1920s to the 1960s (Allen 1956, Flemons and Whalley 1958, Humphreys 1967) and in northern parts of the Northern Territory in the 1950s and 1960s (Cameron *et al.* 1984).

The first recorded presence of buffel grass in central Australia was of a specimen identified from Alice Springs (White 1930) and, following trials (*e.g.* Winkworth 1963), plantings were conducted in this area throughout the 1960s and 1970s for pasture improvement, prevention of soil erosion and dust control (Keetch 1981, Allan 1997). Buffel grass has spread widely from these introduction points and now occurs across all land tenures in central Australia (Puckey and Albrecht 2004). With this expansion there has been a concomitant reduction in biodiversity and alteration of fire regimes. For example, Franks (2002) and Jackson (2005) demonstrated that native plant species richness was lower in *C. ciliaris*-dominated sites than in sites without cover or with reduced cover of *C. ciliaris* in Queensland. The same result occurred in Alice Springs (Clarke *et al.* 2005). In addition, Miller (2003) found that buffel grass invasion in central Australia was significantly correlated with increased fuel load and burn severity. Overseas studies have also reported displacement of native vegetation and reduced plant and animal species diversity in areas where buffel grass predominates (*e.g.* Flanders *et al.* 2006).

While the effects of buffel grass on floral diversity and landscape ecology are becoming increasingly understood, there is very little information on its effects on invertebrate biodiversity in Australia and, especially, on the

identity and provenance of invertebrate species supported by buffel grass. In May 2008, several populations of the sugarcane whitefly, *Neomaskellia bergii* (Signoret), were discovered on uncultivated buffel grass plants growing at one site in Alice Springs. Further surveys were conducted to determine the extent of the distribution of *N. bergii* in Alice Springs.

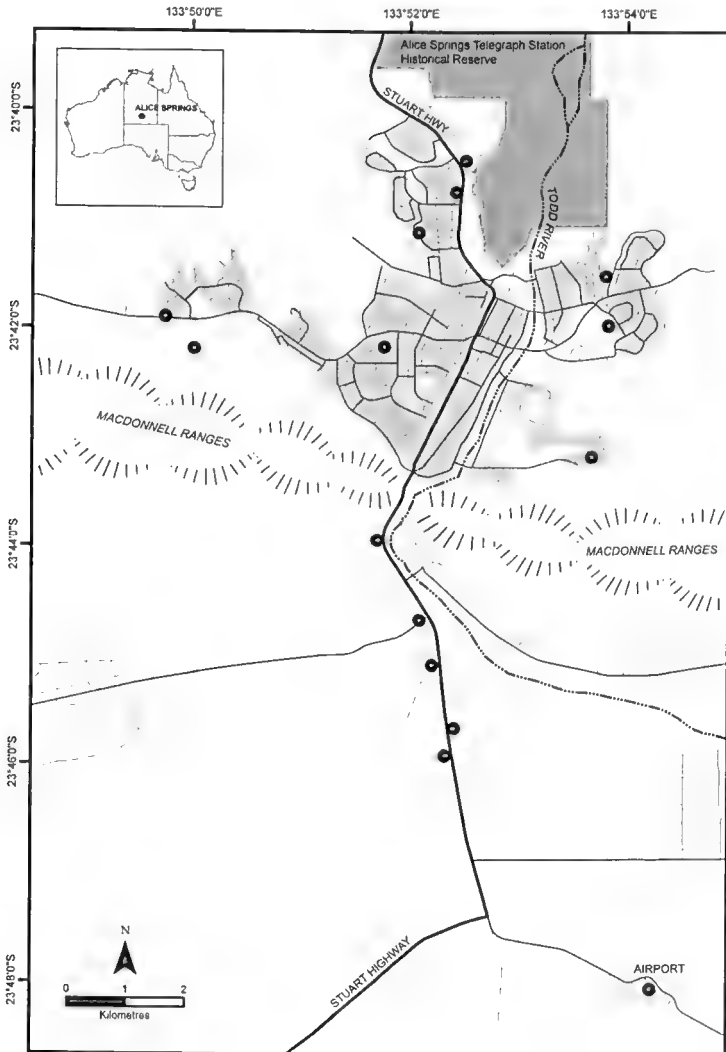


Fig. 1. Map of the Alice Springs area, showing the distribution (●) of the sugarcane whitefly, *Neomaskellia bergii*, in June 2008.

Results

Sampling revealed the presence of *Neomaskellia bergii* at fifteen sites in Alice Springs (Fig. 1). Only three of the eighteen targeted sites did not yield whitefly populations. All plants supporting whitefly populations were uncultivated and grew close to a water source such as stormwater pipe drains or, more commonly, in well-watered ornamental situations such as parks and gardens. Each site comprised between one and thirty colonised plants.

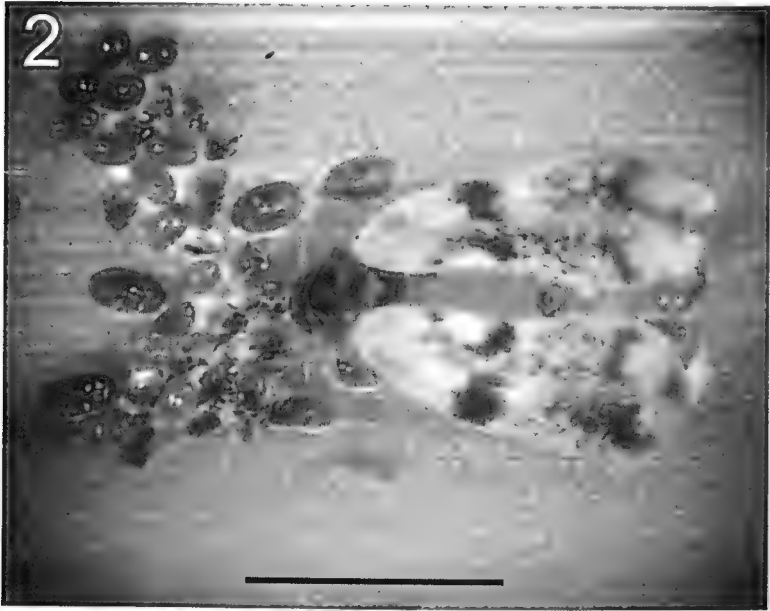
All life history stages (adults, larvae, eggs) of *N. bergii* were usually present on each leaf (Fig. 2), although occasionally single adults or adults with eggs only were observed on leaves. All individuals were crowded on the ventral surface of the leaf blade (Fig. 3), near the junction with the sheath. Most of the whitefly populations were tended by ants from one or more of the genera *Camponotus* Mayr, *Iridomyrmex* Mayr and *Solenopsis* Westwood. Whiteflies were not observed on native grasses (*Dicanthium*, *Enneapogon*, *Enteropogon*) growing adjacent to or among *Cenchrus ciliaris* plants harbouring populations of *N. bergii*.

Discussion

Neomaskellia bergii is widely distributed throughout the Afrotropical, Australian, Oriental and eastern Palaearctic regions (Mound and Halsey 1978). Outside Australia it is known from a wide variety of host plants belonging to the family Poaceae, such as *Bambusa* sp. (bamboo), *C. ciliaris*, *Panicum maximum* (guinea grass), *Paspalum conjugatum* (sourgrass), *Pennisetum* spp., *Saccharum officinarum* (sugar cane), *Setaria italica* (Italian millet, foxtail millet) and *Sorghum* spp (Mound and Halsey 1978).

In Australia, *N. bergii* has been known from coastal Queensland for almost 100 years, where it colonises *Saccharum officinarum*, *Setaria palmifolia* (palm grass) and *Sorghum bicolor* (Carver and Reid 1996, Martin 1999). Despite its long history in Queensland, circumstantial evidence suggests that *N. bergii* is unlikely to be an Australian native, as none of the known host species are native to Australia. This species was first collected from sugar cane near Cairns in 1918 (Carver and Reid 1996) and may have been introduced into Queensland soon after sugar cane was first cultivated in that area.

Based on recent collection records, the distribution of *N. bergii* is expanding. Locality data show that specimens were collected from sorghum in Quilpie, southwestern Queensland in 1993 (the only other record from inland Australia) and the species has more recently been collected from *Paspalum scrobiculatum* (kodo millet, scrobic) in Darwin (Anon. 2001). The current study provided the first record of *N. bergii* from central Australia and this is the first time that buffel grass has been recorded as a host plant for this species in Australia.



Figs 2-3. Colonies of sugarcane whitefly on buffel grass. (2) eggs, larvae and one adult *N. bergii* on the leaf blade; scale bar = 1 mm. (3) typical clustering of adults, larvae and eggs of *N. bergii* on the ventral surface of leaf blades; also visible are ants from the genus *Iridomyrmex* tending whiteflies.

As the sugarcane whitefly has been found at multiple sites, it has probably been present in Alice Springs for some time. With such a large reservoir of populations, other localities in central Australia are also likely to be colonised by this species, but only where sufficient moisture can maintain growth of buffel grass for prolonged periods of time, such as beside waterholes, creeks and stormwater drains, as well as near human dwellings. Inadequate rainfall in the arid zone means that such situations would be sparse; however, the potential for *N. bergii* to colonise areas following periods of above average rainfall is probably high.

Crowding under leaf blades and ant-attendance are distinctive features of both species of *Neomaskellia* Quaintance & Baker (Martin 1999). The presence of all life history stages in most surveyed populations indicates that the species is continually breeding on buffel grass.

The only other insect known to regularly utilise buffel grass as a host in Australia is the buffel grass seed caterpillar, *Mampava rhodoneura* (Turner) (Lepidoptera: Pyralidae), which also occurs in Queensland and which webs together the plumes of seed coats before feeding on the seeds (Cantrell 1981). In this way, seed yield can be significantly reduced (Cantrell 1981, Common 1990). Although *N. bergii* is usually considered to be a minor pest of sugarcane, it has infested the Queensland crop in large numbers (Mungomery 1930) and populations in India have caused stunting and malformation of Italian millet as well as the development of sooty mould (Vasantharaj and Raghunath 1977). The current investigation has shown that, in this case, buffel grass has had a negative effect on biodiversity by supporting a species which is most likely introduced and which affects agricultural, horticultural and natural environments. Buffel grass has also had negative effects on invertebrate diversity in semi-arid regions of other countries, where infestations have led to reduced abundance of arthropods in the U.S.A. (Flanders *et al.* 2006) and likely alteration of ant community composition in Mexico (Bestelmeyer and Schooley 1999).

Acknowledgements

I thank Tim Collins (Alice Springs Desert Park) for first noticing the presence of whiteflies, for assisting with fieldwork and for his help with Figures 2 and 3. Carly Steen (NT Parks and Wildlife Services, Alice Springs) kindly produced much of Figure 1. Laurence Mound (CSIRO Entomology, Canberra) reviewed the manuscript, for which I am grateful.

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AN EXAMPLE OF INTERGENERIC PAIRING IN THE DANAINAE (LEPIDOPTERA: NYMPHALIDAE)

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Abstract

An intergeneric pairing between *Danaus plexippus* (Linnaeus) and *Tirumala hamata* (W.S. Macleay) is reported and illustrated from southeastern Queensland.

Observation

In late March 2005, while walking through the Great Sandy National Park (Cooloolool section) in southeastern Queensland, we observed and photographed (Fig. 1) the danaine butterflies *Danaus plexippus* (Linnaeus) and *Tirumala hamata* (W.S. Macleay) in copula. *D. plexippus* males are known to mate aggressively and force copulation. The specimens were not collected as a photograph was considered a higher priority; hence there was no opportunity to determine whether any progeny might have resulted from this intergeneric pairing.



Fig. 1. *Danaus plexippus* [male] and *Tirumala hamata* [presumed female] in copula at Cooloolool, Queensland.

ENTOMOLOGICAL NOTICES

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